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"But, meanwhile, I may most truly say that, if the crop or timber or fruit growers of India were furnished with plain and comprehensive accounts of history and habits of the common insect pests, accompanied by wood-cut figures, so as to convey the appearance of pests without wearisome description of details, all this would be a national benefit, repaying the outlay a hundred times."

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INTRODUCTION.

As Mr. Lefroy has written this book largely at my instance, I wish to attach a few words in order to explain its scope. It is not a scientific treatise on Entomology, written for the use and training of Entomologists, but is intended to serve the more humble but useful purpose of a manual of practical information for the use of the intelligent agriculturist in the protection of his crops from insect pests. It is also hoped that it will be suitable as a text-book for use in Agricultural Schools and Colleges, all of whose students should acquire a working knowledge of insect pests and of the practical measures possible for the protection of crops. With these objects in view, the author has avoided, wherever possible, scientific terminology, using simple English equivalents which can easily be understood by persons with no scientific training in Entomology.

The information available for a book of even this limited scope is very far from complete. A good deal of work has been done in the past for Systematic Entomology in the collection and classification of some groups of Indian insects, more particularly the Butterflies, but it is only within the past few years that any real inquiry has been made into Economic Entomology, dealing with insect pests and their treatment. For this reason Mr. Lefroy would prefer to postpone publication until the material at his disposal is more complete, but I think first, that the information available is already of sufficient importance to give to the public, and second, that the best way of collecting additional information is to interest persons in that already acquired and to show

clearly the need for further help. For this purpose the many blanks in this book have designedly been given prominence by the author in the hope that many workers will endeavour to fill them up by careful and intelligent study of insect life. The field for future investigation is unlimited. This book is a testimony to the strenuous efforts made during the past three years in this field by Mr. Lefroy, who is the only Entomologist in the Department of Agriculture. It is hoped that in the near future an entomologist may be employed by each important province for the investigation, prevention and cure of crop pests, but this will not lessen the need for other workers, whose assistance will be warmly welcomed by the Government Entomologist. If this help is freely given, I look forward within a few years to the issue of a revised edition of this book, in which still more useful information about insect pests may be given.

F. G. SLY,
Officiating Inspector-General of Agriculture in India.

The 1st May 1906.

PREFACE.

THE study of pests in India dates back twenty years to the formation of the Entomological section of the Indian Museum, the commencement of Indian Museum Notes, and the publication of Surgeon-General Balfour's little volume, "The Agricultural Pests of India." During this time a continuous effort has been made to classify insects injurious to crops, terminating with the work of the late Mr. L. deNiceville, the first Entomologist to the Government of India. It has fallen to me to gather up these records, to supplement them by observation in the field, and to put together briefly what is known of Indian pests.

To any one familiar with the scattered records of Indian Museum Notes, such an undertaking was a necessary preliminary to further work and, above all, to the wider growth of the study of insect pests. Few observers have contributed to our knowledge of insect pests in India, which is deplorable in so vast a continent where so large a population is dependent on agriculture.

In the present volume I have tried to give a short account of the general features of the lives of insects, as well as the salient facts concerning our destructive pests. Those who wish for technical accounts of the anatomy and classification of insects will find abundance of excellent books. We are here more closely concerned with their living activities and the part played by them in the reduction of the yield of the staple crops of the country.

I trust that the book may be of service to many who are engaged in agriculture and horticulture. Insects are universal and quite interesting as soon as one ceases to regard them as mysteries. I cannot hope to emulate the living interest of

the insect world as presented by "Eha," but perhaps the necessary precision of thought and language in this volume may blend with his delightful pictures and help to give a true impression of our insect friends and foes.

Much of the local information in this volume has been obtained from the many reports sent in at the instance of the Directors of Agriculture. In a country where nothing is outside the scope of official enquiry, much may be learnt from enquiries pursued by the Mamlatdar or Tahsildar, and especially in regard to the attitude of the cultivator towards his pests. My acknowledgments are due to the many district officials who have sent in reports of injurious insects and carefully collected information as to the remedies in use among the ryots.

I am under a deep obligation to Mr. F. G. Sly, Officiating Inspector General of Agriculture, to whom the inception of the book is due, and who has endeavoured to bring the arrangement and text into the form most suitable for those for whom it is intended; without this encouragement and advice, the volume could not have been produced in its present form. I have also to thank Mr. C. A. Barber, Government Botanist, Madras, and Dr. H. H. Mann, Scientific Officer to the Indian Tea Association, for valuable help and suggestions in the final preparation of the text. The illustrations are largely the work of the late artist in the Indian Museum, Babu G. C. Chukraburtty, and these have in many cases been published in another form in the pages of Indian Museum Notes. Others have been prepared under my supervision by H. H. Deboo, Chotalal Daulatram Shah and Rambhau Balajee, artists attached to the Department of Agriculture. The diagrams and photos are my own, and Mr. R. C. Wood very kindly prepared the design on the cover.

I am indebted to the work of my staff for many observations; the Entomological Assistants attached to the Departments of Agriculture in the Punjab, Central Provinces and

Baroda have added information concerning injurious pests, and I have incorporated their observations in some cases. I trust that many will be found to follow in their footsteps, to take up the study of insect life in relation to agriculture in India, and to devote themselves to this branch of research. It is certain that India should not be behind other nations in scientific knowledge, and that men can be found who will devote themselves to this form of learning, not for the sake of the pay or position, but at the bidding of that intense organised curiosity which lies at the root of modern science. I venture to hope that this volume may draw others into this work and open a new field for research.

H. MAXWELL-LEFROY,
Imperial Entomologist.

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Part I.

INSECTS IN GENERAL.

CHAPTER I.

INSECTS: THEIR STRUCTURE AND FOOD.

THE word insects recalls the many familiar butterflies, beetles and other flying or crawling creatures that are so abundant. The term is, however, very loosely used and includes many crawling creatures that are not insects in the strict sense of the word, and with which this volume does not deal. It is not easy to give a clear idea of the animals included in the great class *Insecta*. Excepting birds and bats, insects alone can fly; but only a proportion of the insects one commonly sees have reached the flying stage or ever fly. We must, therefore, look for better distinguishing characters. The legs will help us. A great host of small creatures that crawl on earth have distinct small jointed legs. One thinks of spiders, of centipedes, of millipedes, of scorpions, as well as of beetles, caterpillars and the like. Of these, insects have never more than three pairs of legs. A centipede with over 40 legs is not an insect nor is a millipede. A spider with four pairs is not an insect, nor is a scorpion. On the other hand, a caterpillar is, though it seems to have many legs; actually it has three pairs of little jointed

FIG. 1.
A Millipede—(not an insect).

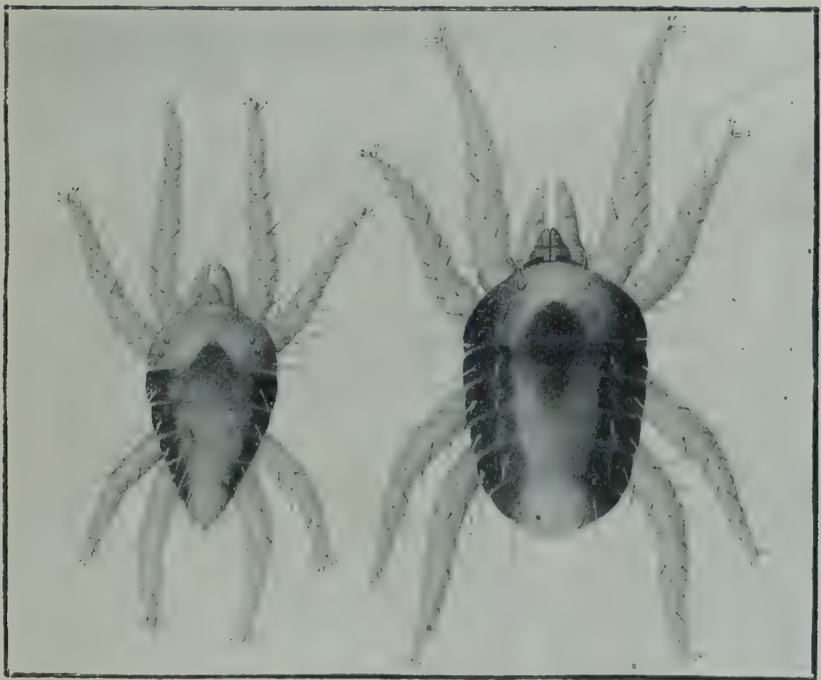

FIG. 2.
Red Spider—(not an insect).

legs, but also has five pairs of little sucker-feet to enable it to crawl along a leaf. Our insects then, if they have no wings, should certainly have not more than three pairs or six legs. They also have the feelers on the front of the head.

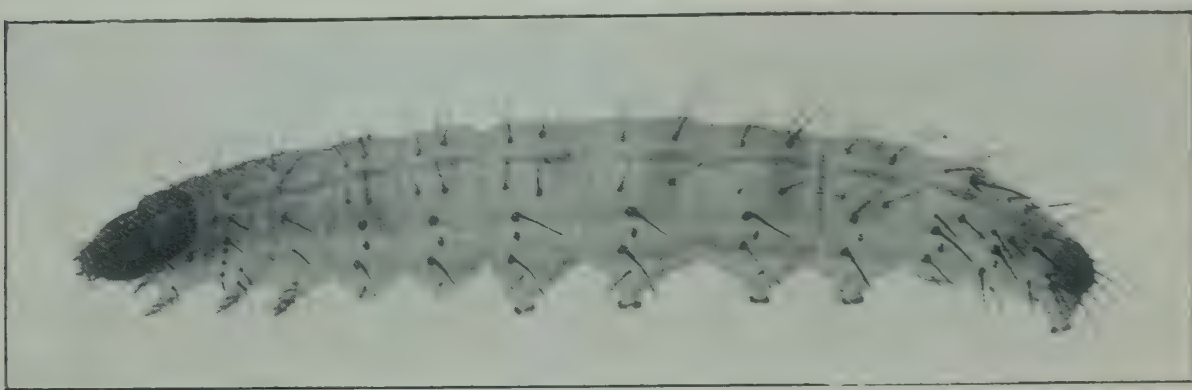

Fig. 3.
Typical Caterpillar.

But on the other hand there are maggots, for instance, that have no legs. They look like worms, but are distinguished by many small points of structure. One can only remember that a maggot is one stage in the life of an insect and will become a fly with wings and six legs. There are also insects that have anything but the general form of insects; they are however rare, and if we keep clearly in our minds that spiders, centipedes, millipedes, scorpions and such-like eight or many-legged creatures are not insects, we are not likely to be confused. For those who want a more exact and scientific definition, there are excellent books on zoology and comparative anatomy, where the distinctions are expressed in more scientific terms.

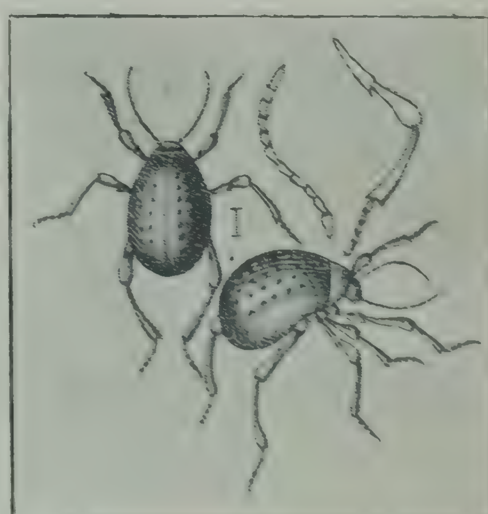

Fig. 4.
An insect (beetle) which resembles a mite, but has three pairs of legs.

An insect's body is completely clothed in hard durable material within which the organs lie. This is not one continuous covering, but is formed of rings joined end to end by flexible connections so as to enable the insects to crawl and move about. These rings overlap a little and so present an unbroken hard surface to the outside. Within this flexible tube of rings lie the soft parts, the muscles, nerves and all organs; attached to it are the legs, wings, jaws, and other parts.

If we take a caterpillar and examine it we find the following parts :—

The head is rounded, broadly attached to the body ; the mouth is situated on the lower side with a complex arrangement of jaws ; small

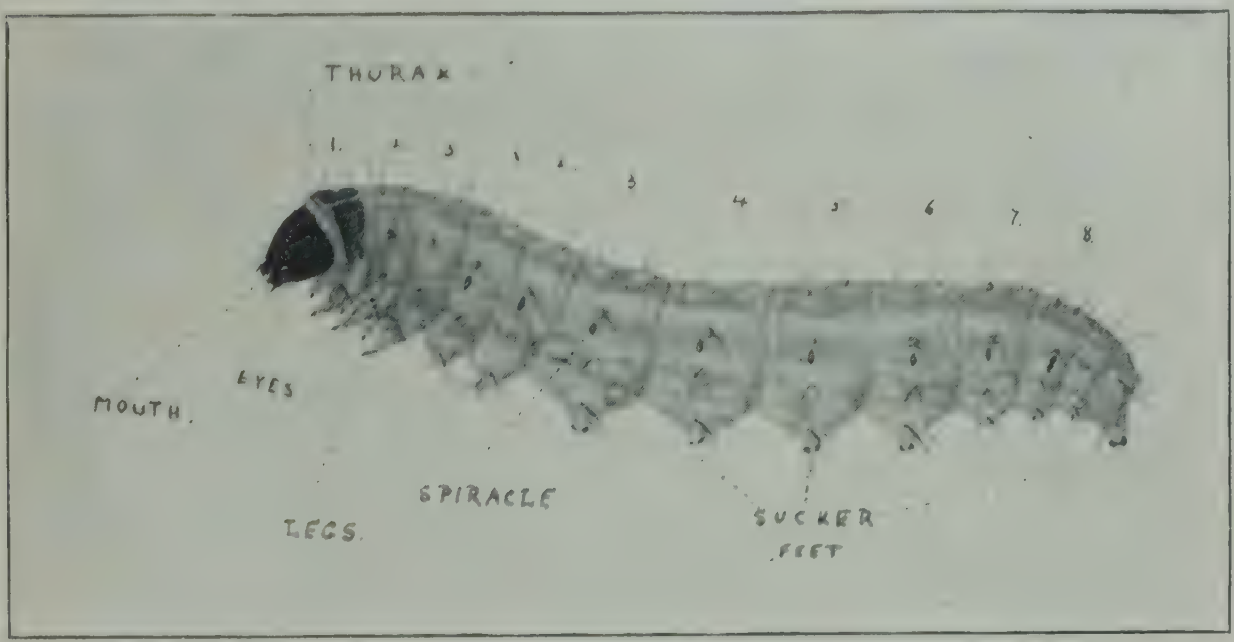

FIG. 5.
Caterpillar.

eyes are set in a half circle on each side of the head ; and we may discern a pair of small feelers called *antennæ*. Behind the head are three segments (a ring and the contents are called a *segment*), each having a pair of small jointed legs below : there are short or long hairs on each segment, and the first segment often has a small oval shield just behind the upper part of the head. These three segments together form the thorax.

Behind the thorax are eight segments (which form the *abdomen*),

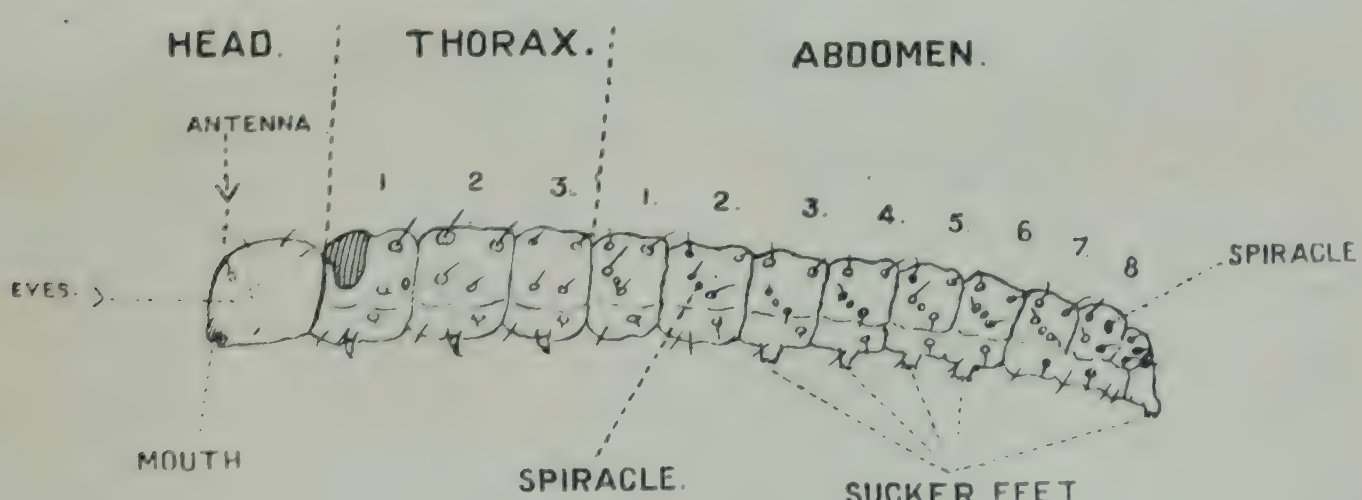

FIG. 6.
Diagram of Caterpillar.

and the last one or two which we may call the tail. These segments are nearly alike, but the four in the middle usually have a pair of small projections on which are hooks; these are sucker-feet and there is a fifth pair on the tail. Each of the eight segments has a small dark spot on each side, and a similar spot is found on the thorax; these spots are *stigmata*,[1] or air openings, which admit air to the system of air tubes inside the caterpillar's body. The hairs or bristles found on the segments and the tail are not scattered haphazard, but arranged in a definite manner.

FIG. 7.
A Wasp, showing the divisions of the body in a winged insect.

These are the salient points that can be seen in any insect. In all insects the head, the thorax and the abdomen are distinct; the head always bears the eyes, the mouth and jaws and the feelers (*antennæ*); the thorax always bears the legs and the wings and is actually composed of three segments, though we cannot always see the division; the abdomen bears sucker-feet in some insects only and has a varying number of visible segments in different insects. Stigmata, or air openings, are found in all insects, and usually are arranged as in the caterpillar.

All insects have a more or less hard covering, which is composed of a substance known as *chitin;* this is a nitrogenous material, peculiarly resistant to chemicals, which forms an impervious covering. The legs, antennæ, wings and all parts of an insect are covered in it; the thick hard wings of a beetle, the fine scales of a butterfly and the flexible skin of a caterpillar are largely composed of it.

Speaking generally, the skeleton of an insect is this outer covering; there are no "bones," but a few chitinous supports of the internal organs. When an insect is killed and dried the whole body perishes except the chitinous covering, so that a pinned collection only consists of this dried *chitin*. Such insects as have not a sufficiently thick covering must be kept in spirit, so that the internal organs may be preserved in order to maintain the natural form of the insect.

[1] *Stigma*, a spot; plural, *stigmata*, spots.

In distinguishing the different classes of insects, it is necessary to look specially at the wings and the mouth-parts. In mature insects there are, as a rule, two pairs of wings: the first pair (upper or fore-wings) attached above the second pair of legs, the second (lower or hind wings) attached above the third pair of legs. In some insects the second pair of wings is not present or is transformed into a different structure. In a few the wings are never developed, the mature insect being wingless or having imperfectly developed wings. (Figs. 16, 30, 40 and 51.)

FIG. 8.
Fly, to show the second pair of wings reduced to balancers.

The "mouth-parts" (jaws) of insects are the structures that surround the mouth and which are used for feeding. These structures are somewhat complicated and are specially formed in accordance with the habits of the insects. Insects that bite leaves or green plants have short biting mouth-parts, with cutting teeth; insects that attack other insects have usually long sharp jaws, suited for grasping their prey; those which suck the juice of plants have a slender tube-like beak, with sharp instruments for piercing the plant; those also which suck the blood of animals or insects have a sharp tubular beak, as in the mosquito. It is important to be able to recognise the differences between these kinds. A few have mouth-parts not included in either of the above kinds; thus the bees have very complicated jaws, which are fitted for lapping up the nectar in

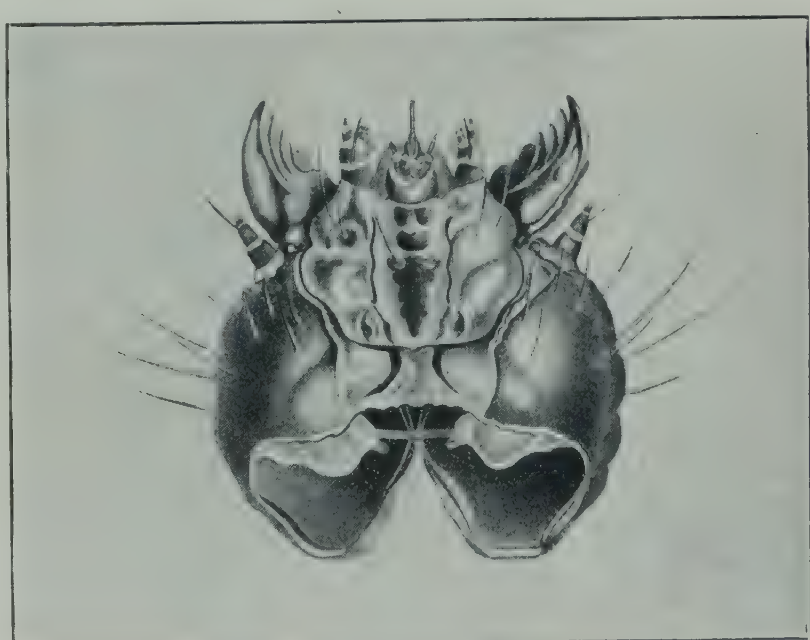

FIG. 9.
Head of a Caterpillar, from beneath. (From Lyonnet.)

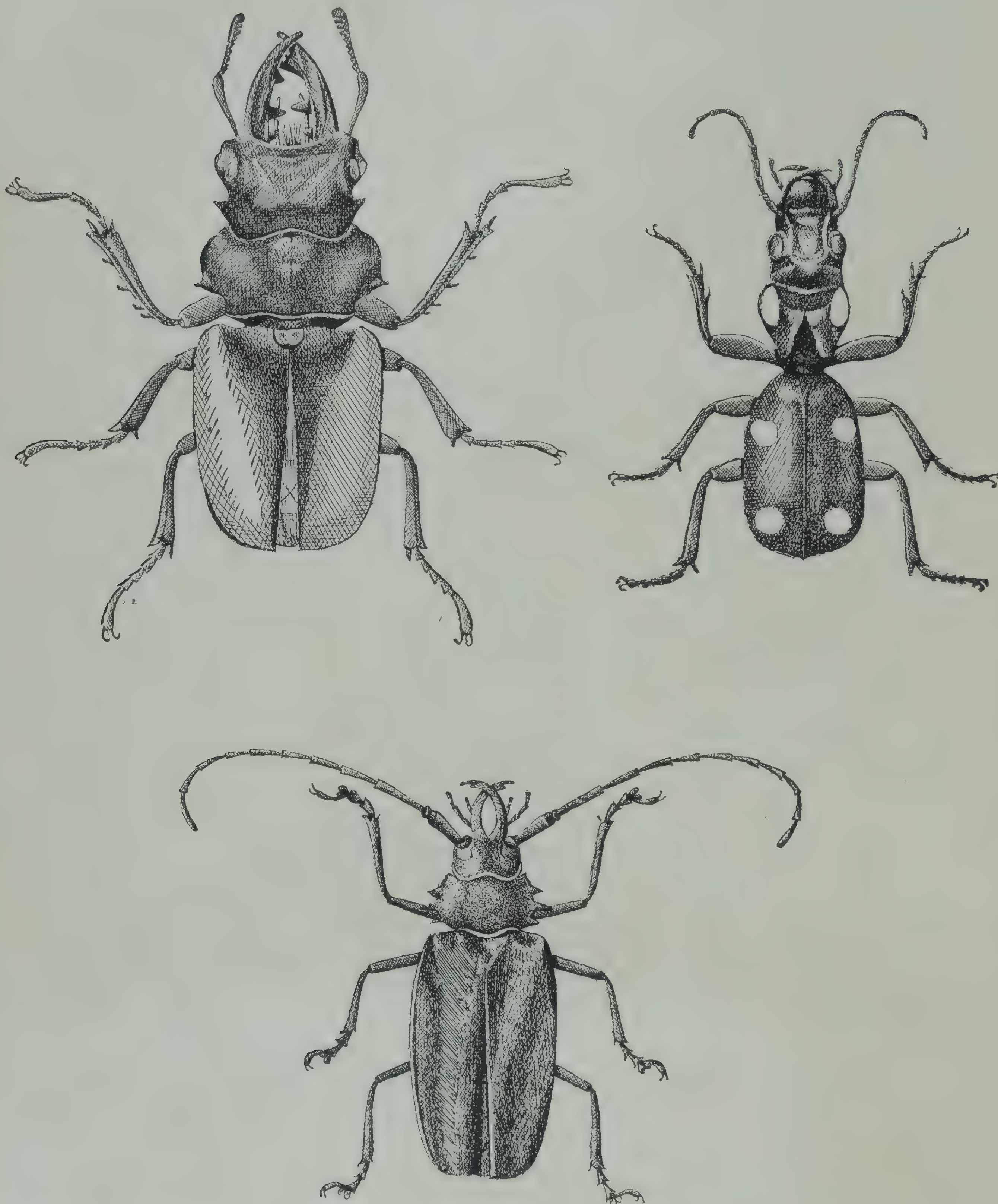

FIG. 10.
Three carnivorous Beetles with long mandibles.

flowers and also for biting; the butterflies and moths have mouth-parts formed like a long slender tube which can be stretched into the bottom of flowers to extract the nectar. Figures 11—15 will show the appearance of these mouth-parts, and it is important to look always at the mouth-parts of insects, since this at once gives a clue to the probable habits of the insect.

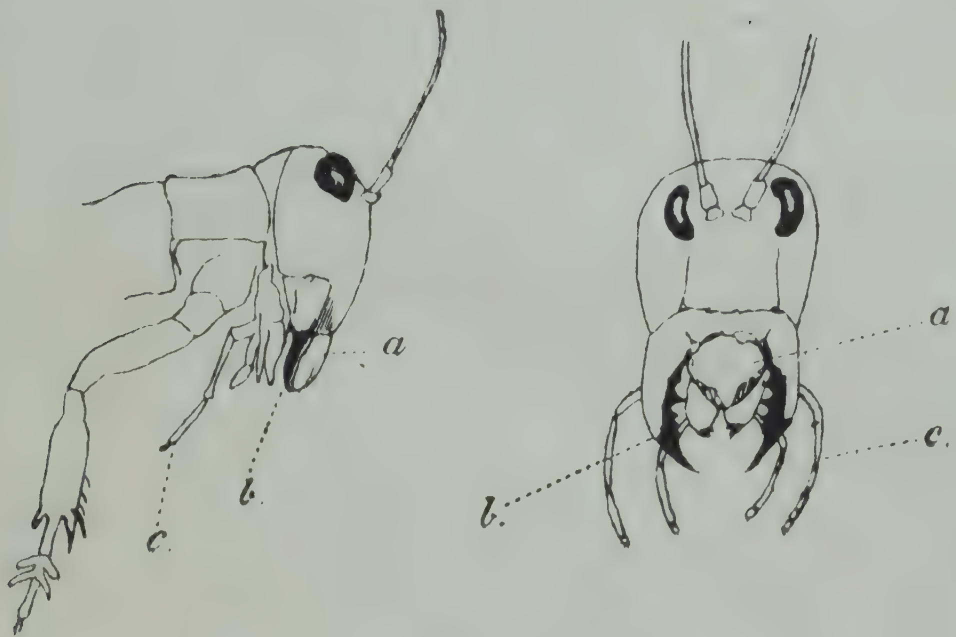

FIG. 11.
The biting mouth-parts of a Cricket.
a. *Upper lip.* b. *The strong toothed mandibles.* c. *The sensory palps.*

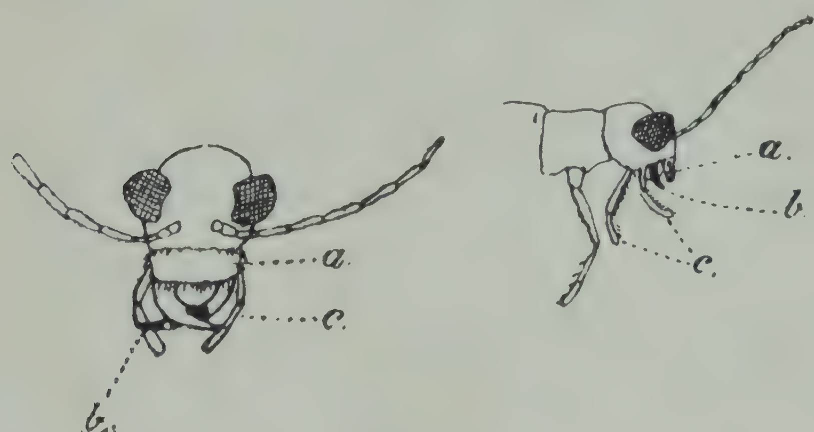

FIG. 12.
The biting mouth-parts of a Beetle.
a. *Upper lip.* b. *The strong curved mandibles.* c. *The sensory palps.*

FIG. 13.
The sucking mouth-parts of Diptera.

FIG. 14.
The curled-up proboscis of a Butterfly.

FIG. 15.
The curled-up proboscis of a Moth.

The bodies of insects are made up of muscles, nerves, organs and other parts just as other animals are, and they live in a very similar way. The food taken in at the mouth passes into the stomach, and is digested; the remains are excreted. The stomach and intestine form a plain long tube which passes from the mouth to the tail. The digested food passes into the space between the skin and the intestine, in which all the muscles and nerves lie; above the stomach and intestine there is a small heart, consisting of a long slender tube which pulsates and pumps the dissolved food forward over the head and all round the body; this can be seen in many caterpillars, if the upper part of the body is intently watched for some minutes. In the body there are numerous muscles, which enable the insect to move. In the head there is a small brain, and running down the lower side of the body there is a double cord of nerve tissue, with little swellings in each ring. This cord is like our own spinal cord, and from it nerves go to all the parts of the body. Insects have nerves similar to our own though on a simpler scale. Besides these organs, the perfect insect has reproductive organs, male or female. These open at the hind end of the body, just below the opening of the intestine. In many insects the female has attached to the hind end of the body a special instrument for laying eggs; the sting of the bee is really the egg-laying instrument: in some insects this structure, called an *ovipositor,* is very large and conspicuous (fig. 52).

Insects have senses and sense organs which we may compare with those of other animals, though we cannot pretend to understand them.

Eyes take the form either of a pair of large conspicuous structures on the side of the head or of several small points on the upper surface or side of the head. The former, known as *compound eyes,* we may consider as hundreds or thousands of small eyes united to form a single complex structure; we can see these separate small eyes which give the whole eye a honey-comb appearance. The latter, known as *simple eyes,* are found in caterpillars and other immature insects, which do not have compound eyes, and also in many mature insects in conjunction with compound eyes. The caterpillar has five or six such eyes on each side of the head; the grasshopper has three only, some bugs have two, and many insects have none. The function of eyes is not clearly understood, but it is believed that the compound eyes are as efficient as our own eyes and that simple eyes perhaps serve to distinguish light and shade or act in some such simple manner.

Organs of hearing are present probably in many insects, but definite organs similar to our ears are known only in the grasshoppers and their allies. Many other insects probably hear sounds, since many of them also make sounds, but it is not certain what is the organ of hearing,

The sense of smell is also probably present, and is believed to lie in the antennæ. Some insects (*e.g.*, locusts) can almost certainly smell water, a feat we are incapable of because our olfactory organ is always damp. Others can certainly smell flowers, carrion, etc., and their sense of smell is probably far keener than our own.

Taste is believed to be a sense functional through certain organs in the mouth-parts.

Touch is another sense probably connected specially with the antennæ and the little palps on the mouth-parts.

Other senses that we do not now use certainly occur; possibly we were once possessed of the "sense of direction," as many insects are; other obscure senses we are able dimly to perceive only after a close study of the habits of insects, although we cannot connect any special sense organs with them. Among these we may include the very peculiar sense shown in the phenomenon known as "assembling." It is known that if the females of certain moths are exposed in a cage, the males of those species will come in numbers and from considerable distances. These distances in some cases extend to several miles. By what sense the males become aware of the presence of the female is not known. The phenomenon is utilised in the rearing of wild silk moths in India, the reared female attracting the wild males from the jungle.

It is impossible to discuss the senses of insects in further detail in this book. Man cannot hope to comprehend them. The fact that a butterfly knows "by instinct" the plant on which its young will feed seems marvellous when we recollect that the butterfly could not remember what it fed on as a caterpillar, the metamorphosis having come after its caterpillar stage and obliterated its memory of larval life. There are countless instances of this kind, and we can only study the activities of insect life with admiration at the wonderful "instincts" and senses with which they are endowed.

Among other curious phenomena may be marked the formation and migration of swarms of insects, such as locusts. This phenomenon is also little understood; it occurs in a small number of insects belonging to different families. The locusts are the best known instances in India, two kinds of which move in swarms over many hundreds of miles. It occurs also in moths, butterflies, dragon-flies, in the larvæ of certain flies and in caterpillars. Large numbers of these insects gather together, form swarms and migrate from place to place. This phenomenon probably originates in the necessity of moving to fresh places in search of food. Insects which multiply very rapidly into enormous numbers may have found it a necessity to move often, the habit thus becoming a settled one,

Food.

From the moment that an insect hatches, its first task is to provide food by its own exertions; it has also to escape the enemies and dangers that surround it; lastly, it has to lay eggs in the proper situation and in some cases must provide for the young. These are the three prime necessities of the insect's life, and though in many cases it is possible that the gratification of a taste for other pleasures is an object in life, we may interpret the activities, the form, colour and structure, even the life history of insects in terms of these three principal needs.

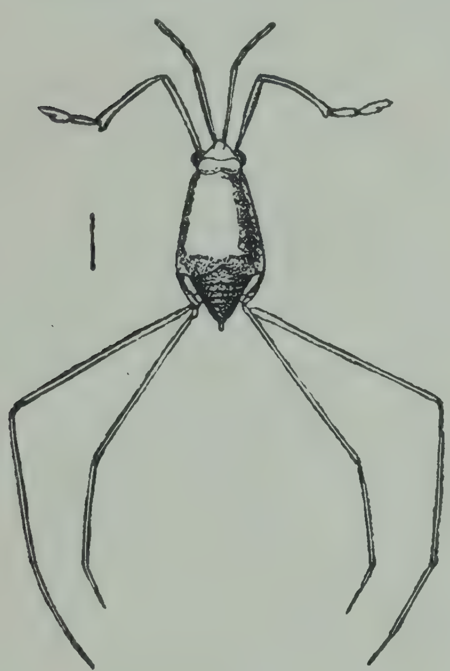

FIG. 16.
Wingless Perfect Insect: the insect lives on the surface of the sea and has no need of wings. (From Distant.)

The food of insects is extremely diverse, and it is not always clear how they are able to extract the requisite amount of nutriment from the substances they consume. We may at once abandon the idea that nutrition is comparable to that of domestic animals. Digestion, nutrition and respiration are very different in insects. What proportion of proteids, carbohydrates and fats is necessary cannot be stated. The amount of food or of air necessary to existence may be reduced to very low limits since insects are not warm-blooded; in the absence of muscular activity there is probably no wastage of the tissues, no consumption of oxygen, no elimination of water or of waste products. The amount of food or oxygen assimilated may be measured by muscular activity and may cease entirely when this ceases. Bearing this in mind, we need not be astonished at the insects which live solely in dry wood, in burrows without access to the air, or which feed solely on chillies, opium or tobacco. Such insects do not drink, they simply eat, and we are entirely ignorant of their digestive and nutritive processes. Nor is it astonishing that many insects can live for many months without food.

Most insects live on land, a few on or near the sea, many in fresh water. Marine insects are few; some in the sea itself, some on the surface, a larger number on the beach or in rock-pools. Relatively, the number is very small, and sea water presents an almost impervious obstacle to insect life. Fresh-water ponds, streams, tanks, and other supplies

of water teem with insect life. Their habits are of great interest and the devices with which they supply themselves with air are amazing in their diversity and ingenuity. Unquestionably the aquatic insects are descended from air-breathing land insects, and for every species the problem of extracting air from the water or of drawing a supply from the surface has been solved in a more or less ingenious manner. These insects, however, form a division apart, cut off by their diverse habits from the insects living on dry land.

The vast majority of insects live on the land, establishing themselves in every possible situation, with the most diverse occupations and methods of obtaining a living. At this period of the earth's history they are the dominant group, the most successful and prosperous, taking toll of all other creatures. In number of species, in actual numbers or bulk, in the sum total of their activities, they outweigh all other forms of animal life at present on the earth. The extraordinary diversity of their habits and food, their rapid multiplication, their small size, their varied powers of locomotion, of offence and defence, and the marvellous instincts and senses with which they are endowed, all these serve to put them above other forms of animal life. Man prides himself on conquering nature, on being the highest expression of animal life, the crown of creation: a dispassionate examination of insect life reveals that even man's powers are as nothing to those of insect life, his senses weaker, his sociology and conduct of life far inferior to that of the social insect, and he himself comparatively lacking in the exhibition of altruism and right conduct shown by an insect.

Fig. 17.
Stages of Fly whose maggot lives in the leaf of the tea-plant.
(*From drawing by E. E. Green.*)

Insects are small and their domination is not apparent; but they have established themselves in every nook and corner of the earth, deriving their food from a vast number of sources. Many feed on plants, living in every part of the growing plant, from the fruit to the roots; eating the flowers, boring in the stem, mining in the leaves; they devour the leaves, destroy the bark and

eat the roots; they suck out the sap and live as parasites upon all parts of the plant. Perhaps one-third of the total number of insects live on plant life directly, thus constituting one big division called the *Herbivores*.

There are others which live on the dead or decaying plant, on dead leaves, on rotting fruits, on dry timber. Any vegetable tissue that is no longer alive and growing furnishes food to this division. We may include with them the feeders on decaying animal tissue, such as the dung feeders, the carrion beetles, the corpse buriers. We may term them all *Scavengers*, since they, with the bacteria and fungi, cleanse the earth of its rubbish and convert it into good plant-food again. They also form a large division, not less important but far less visible to us, working in the dark and in hidden places.

As the plant world furnishes food for so many insects, so also these insects in turn are fed on by others, and we find a very large division which get their food from the herbivorous and scavenging insects or from each other. These work in two ways, by preying upon insects and eating them bodily, as a tiger eats a cow, or by living within their bodies parasitically, as a tapeworm lives in a horse. The former, the *Predators*, we see daily at work and we may compare them with the many insectivorous birds. The latter, the *Parasites* (Ichneumons and flies), are not less numerous and abundant; their larvæ live in the insect, absorbing the food laid up by the host and gradually killing it. The two groups together check the immense increase of insect life and form the third great division.

There are also a small number of insects that live parasitically in or on warm-blooded animals. They feed on the blood of man, cattle, wild beasts, birds and other animals, or live parasitically within their bodies. They form a small division.

There are lastly the insects which have found that man offers many comfortable homes in his houses and buildings; they live upon grain, flour, drugs, all manner of produce and household stores; they inhabit our houses, deriving a precarious existence from what they can pick up. These are the household pests; they have been carried in ships to all parts of the world and established themselves wherever man is. This division is not large or very important but an aberrant and distinct offshoot from the great scavenger class mentioned above.

We have now included practically every insect in our divisions, and if we subdivide them, almost every species whose habits are known would fit in. We see the part each plays in the great cycle of life. The herbivores feed on the plants, which build up organic matter from the soil and air under the influence of the sun. These herbivores build up the plant tissue

into more complex organic compounds and in turn supply food for others. The scavengers feed on the decaying plant life and animal life, clearing the earth of decaying refuse, making it clean and sweet; eventually they die and the whole mass of organic material breaks up into the compounds available for plant life. The parasites and predators feed upon the living insects, checking the increase of both herbivore and scavenger, so that the destruction of living plant life by herbivores can then never go beyond a certain point, the balance thus being maintained. We are in this volume mainly concerned with the herbivorous insects, those which feed upon the living plant. They are largely injurious to man, though also beneficial. We cannot neglect the parasites and predators, for in actual work we meet them at every turn; the part they play is not very evident, but the practical study of pests requires that every student of agriculture should be familiar with them and recognise them almost at a glance. The scavengers are not of direct importance and we see them but little; grain and household pests are of direct importance to man as also the insects parasitic upon cattle and warm-blooded animals.

Food Plants.

Caterpillars and other herbivorous insects may have one, a few, or many plants on which they can feed and thrive. Evidently an insect that can live on a variety of plants has an advantage over one that lives only on one or a few, and injurious insects are largely those which have a great range of food-plants, enabling them to spread widely, to increase abundantly, and to find food when crops are not available for them. The list of injurious insects is nearly synonymous with the list of insects having many food-plants.

In general, insects feed upon one or more closely allied plants; thus cotton pests are found also on *bhinda* and other species of *Hibiscus*, cane pests on maize and sorghum, and so forth. In other cases they feed on plants which bear similar fruits; an insect that eats the oily seeds of cotton will perhaps feed on the oily seeds of other plants not closely allied to cotton.

The food-plants of some species, *e.g.*, the gram caterpillar, are to be numbered in scores. The food-plants of others are few, and there are insects, for instance, which can feed on certain varieties of cotton and not on others. The composition of the tissues of the plant probably determines its suitability to insects, and some plants appear to have no pests. Plants protect themselves in various ways, but insects in their turn seem equally to accustom themselves to the oils, alkaloids, hairs,

thorns, etc., with which plants have tried to render themselves safe. Modern science has not yet discovered any method of altering the composition of plant sap so as to render it distasteful or poisonous to insects. When this subject has been mastered, we shall be in a position to deal more successfully with insects by purely preventive methods.

CHAPTER II.

LIFE HISTORY AND HABITS.

INSECTS pass through various changes during their lives, changes of form, habits, structure and the like; these transformations are in many cases very great, being the most striking characteristics of the life history of insects. Whilst the life history is essentially the same throughout large groups of insects, it is not exactly the same in any two species. We can give here only a very brief outline, but fuller details will be found in the later sections.

Insects are hatched from eggs, which, though smaller and different in appearance, are essentially similar to those of birds. These eggs are not cared for by the parent insect, but are laid in such a position that the young when they emerge will find suitable food.

From the eggs hatch out tiny insects which are usually able to feed almost at once and begin their active life without delay. They feed voraciously and rapidly grow larger. Their chitinous skin will, however, not stretch and permits of growth only to a certain limit; when this is reached, a new soft skin is formed under the old one; the latter splits so that the insect crawls out with only the new soft skin; the insect at once expands, the new skin hardens with the result that our little insect is suddenly twice its previous size and perhaps very different in appearance. Growth again continues until the insect is too large for the second skin, when the process is repeated and a fresh moult undergone. The skin is thus shed periodically until the insect attains its full size and mature form. At every moult the appearance of the insect changes; it may be a minute change in appearance with a considerable change in size, or it may be a complete change of form, with change of habits and structure. The number of moults varies from two to twenty or more, but is generally about five to seven.

These changes form the essential part of the life history of insects. We can now examine in detail the nature of the changes undergone in the great groups of insects.

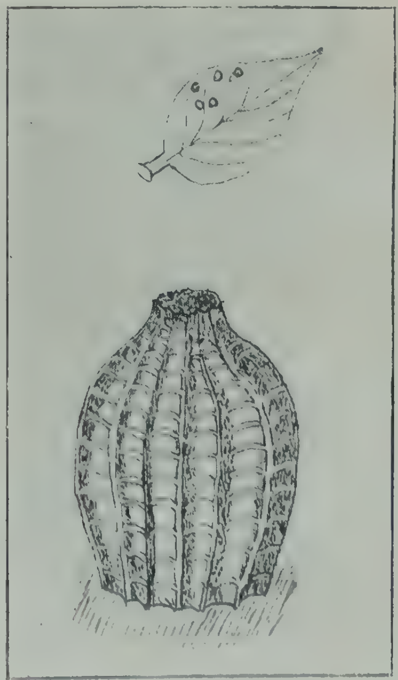

FIG. 18.
Eggs of a Butterfly; natural size on a leaf, and enlarged.

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If we catch a female butterfly, for instance, the very common one that is figured (fig. 24) and keep it in a suitable cage, it will lay eggs. These eggs are shown in figs. 19-20 much magnified, and in another figure (fig. 18) are shown the eggs of another butterfly both magnified and natural size. The eggs are small white seed-like things and laid singly on the leaves of a plant. If we keep these eggs, they will presently hatch into caterpillars (fig. 21); these are somewhat worm-like in appearance, with legs and sucker-feet, totally different from the butterfly

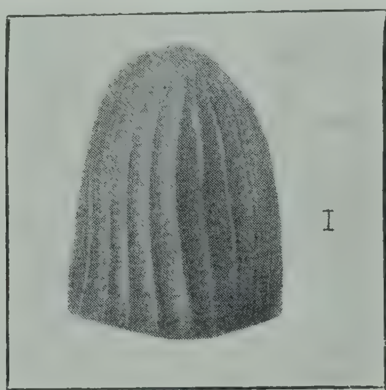

FIG. 19.
Butterfly Egg. (Magnified.)

FIG. 20.
Egg after Caterpillar leaves it. (Magnified.)

in habits and structure. These caterpillars eat the leaves of the plant and moult as they grow larger; at each moult the colour changes very slightly, and the caterpillar comes out much larger. There are five such moults, and at the end of twelve or fifteen days the caterpillar has attained to its full size (fig. 22). It now ceases to feed, becomes

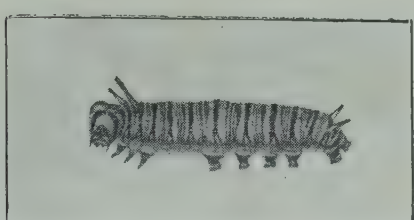

FIG. 21.
Young Caterpillar.

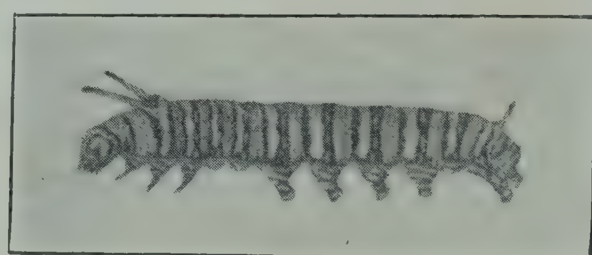

FIG. 22.
Full grown Caterpillar.

uneasy; it is preparing for another moult. To do this it fastens a small pad of silk at some point on the leaf of the plant, and fixing the hooks of its tail sucker-feet in the silk, hangs itself head downwards from the pad of silk. The skin bursts and is thrown off and the insect is seen hanging from the leaf. It is now completely changed in appearance and is called a chrysalis;[1] it is a rounded, green object, with pretty gold markings (fig. 23); there are no limbs, no mouth, no eyes; spiracles alone can be seen. This curious creature hangs motionless from the plant for

[1] *Chrysalis*; plural *chrysalides*.

six days, taking no food and appearing to be asleep. At the end of six days, the outer skin bursts, and a large insect comes out. This walks feebly about for a few minutes whilst its large wings expand and spread out; these wings become firm and stiff and we see that it is the butterfly again (fig. 24) similar to the one first caught. This butterfly will fly away, mate and again lay eggs, which will again hatch to caterpillars, the cycle beginning again.

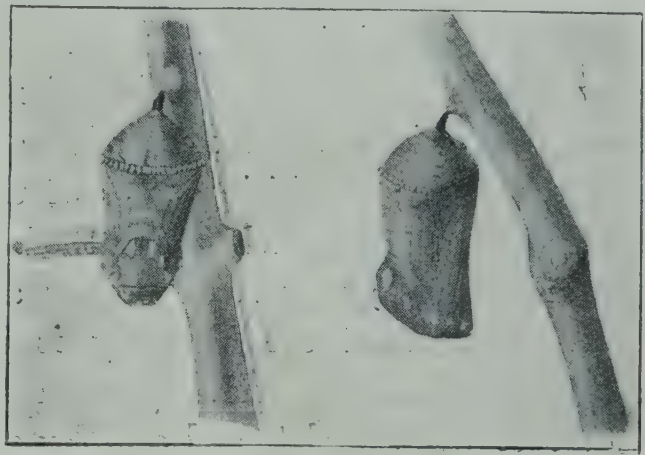

FIG. 23.
Chrysalis of the Butterfly.

This is a very short description of what occurs in the life of this butterfly and similar changes take place in the life of every butterfly. We see in it four stages—the egg, the caterpillar, the chrysalis, and the butterfly.

During the egg stage the caterpillar is formed from the germ; the caterpillar feeds, grows larger and moults; at each moult there are only small changes, and during the growth in size, covering five moults,

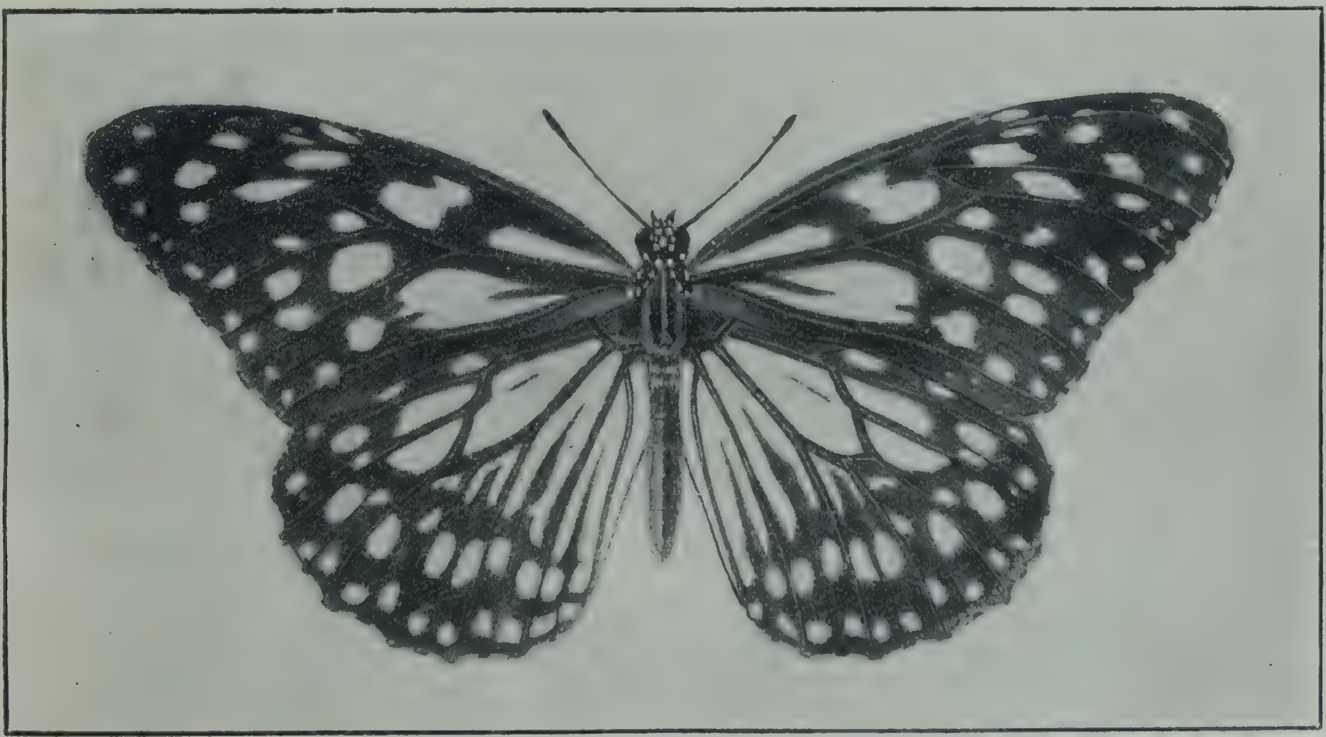

FIG. 24.
Butterfly.

the insect changes but little; its whole business is feeding, growing larger, and laying up a store of fat. When the caterpillar is full grown,

the big change takes place; for this it prepares by hanging itself in a convenient place, out of the way of enemies, etc., and becomes the chrysalis. During this period an internal transformation takes place and the tissues of the caterpillar build up the butterfly. There is no process akin to this in any domestic animal with which we are familiar; every part of the caterpillar is built up anew; the internal organs are remodelled; wings are formed; long legs take the place of the short caterpillar legs; the biting jaws of the caterpillar have been thrown off and the long tubular proboscis of the butterfly is formed; new compound eyes are formed; new sense organs appear. Further, the entire reproductive system of the butterfly is built up and formed. Only the beginnings of a reproductive system are to be found in the caterpillar, but a more or less complete and complex system of reproductive organs, male or female, is formed during this stage. When, at the end of six days, the butterfly within is fully formed, it emerges; the skin is soft, the wings soft and folded up; in a short time the wings expand, become hard and dry; the body takes on firmness, the legs become stiff and the butterfly is ready to fly away, with new senses, new instincts, to suck the nectar from the flowers, to find its mate and to flutter gaily in the sunshine—a change as great as we can imagine from the crawling caterpillar that hung itself up six days before.

The life of all insects is not exactly similar to that of the butterfly, and we may take the life of a grasshopper as an example of what changes take place in some other insects.

FIG. 25.
Egg mass detached.

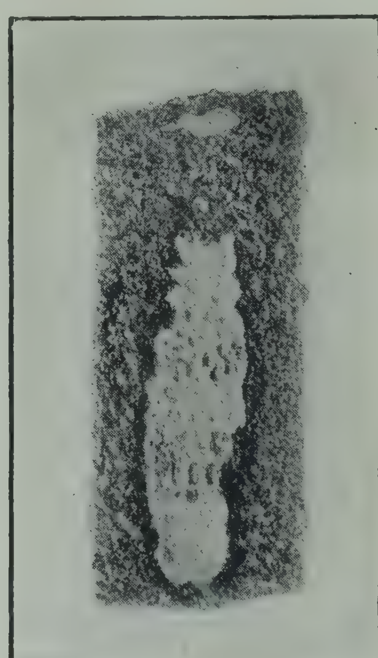

FIG. 26.
Egg mass in ground.

The female grasshopper lays a mass of eggs (figs. 25, 26) in the ground and shortly after dies. These eggs lie in the ground for some weeks and presently each splits and a young insect comes out. This young insect is very small, about twice the length of the eggs, and very active. The general form is like that of the parent; there are the long legs, the hind pair very large (fig. 27), and the head like that of the grasshopper with similar antennæ and jaws. But there are no wings and the little insect can only leap. It is also quite distinct in colour. It feeds upon green plants just like its parents did and grows larger. Moults take place as in the caterpillar, and at every moult the insect comes out larger and somewhat differently coloured. At the fourth moult (fig. 28) two lobes appear at the upper side of the body, on the second and third segments of the thorax, above the second and third pair of legs. At each later moult these grow larger until with the sixth or seventh, they take the form of the large perfect wings. Our grasshopper (fig. 29) is now full grown and moults no more. It has perfect wings, a fully developed reproductive system, and will presently mate, lay eggs and die.

FIG. 27.
Young Insect, one day old. (Magnified five times.)

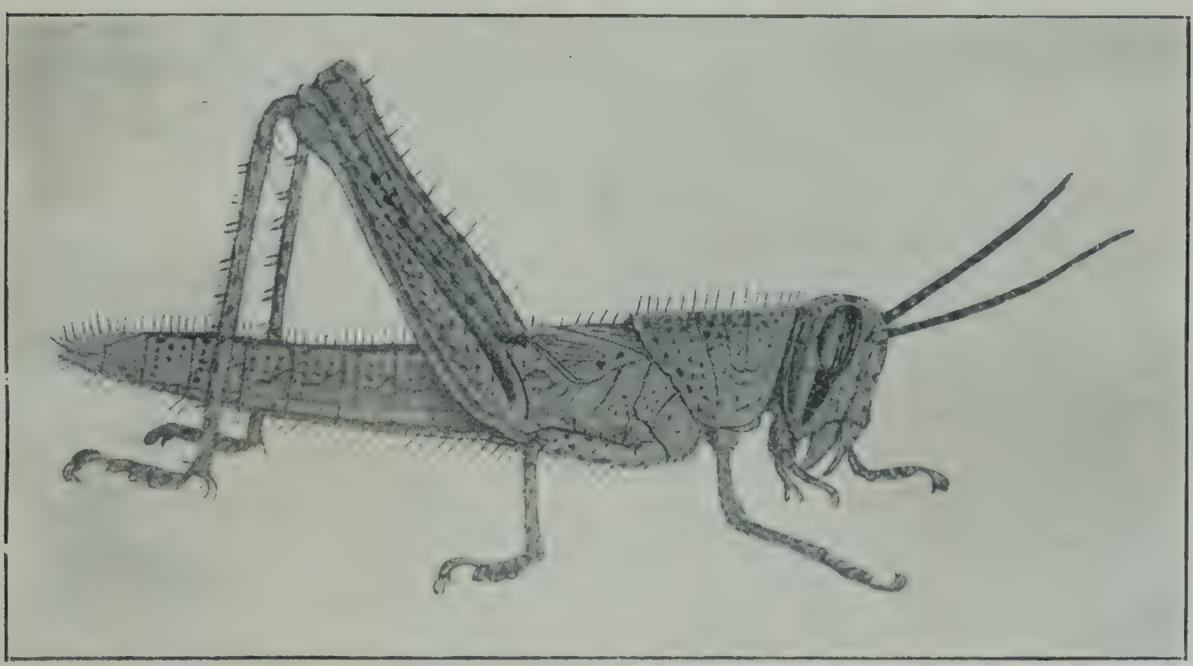

FIG. 28.
Half-grown Insect. (Magnified twice.)

This life history is a great contrast to that of the butterfly; the young is like the parent in general form, feeds in the same manner and

lives a similar life. At each moult it grows larger and gradually changes, almost imperceptibly, till it is full grown. There is no caterpillar, no *chrysalis;* there are no sudden changes at any moults; the wings grow slowly; the reproductive system is developed gradually; there is no period of rest, and the insect feeds at every stage of its life. We may concisely state that whilst the grasshopper develops gradually, the butterfly does so suddenly. The sudden change from caterpillar to chrysalis, and chrysalis to butterfly, is one distinguishing feature; this is called the *metamorphosis,* and all insects which pass through these changes are said to have a "metamorphosis." It is a convenient word which expresses the facts that (1) the young insect is totally unlike the mature insect; (2) between the two is the resting stage similar to that we call *chrysalis.* We might divide all insects into two groups, those which are caterpillars and chrysalides before they become butterflies, and those which change gradually and slowly till they become grasshoppers. The first have a metamorphosis, the second have none. Speaking generally, all insects belong to one group or the other. They either have

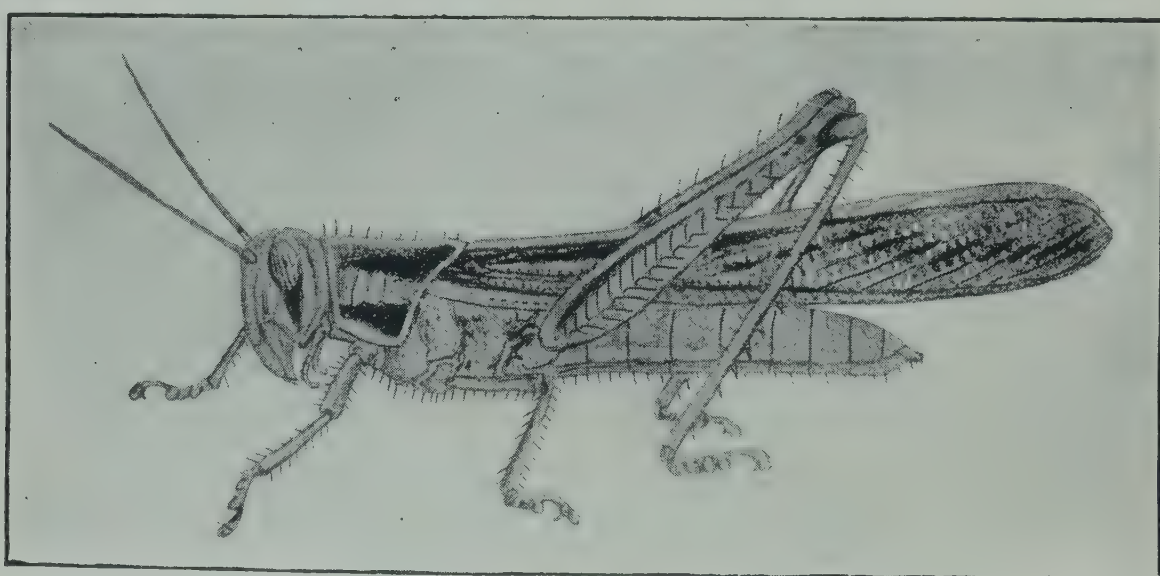

Fig. 29.
The perfect Insect.

metamorphosis and pass through four stages, *viz.,* (1) the egg; (2) a stage like the caterpillar (called *larva*); (3) a stage like the chrysalis (called *pupa*); (4) the mature stage like the butterfly (called *imago*); or they have no such distinct stages but commence as eggs, pass through a series of gradual changes during which we may call the insect a *nymph,* to the perfect insect, called the *imago.**

It will be seen that we have here a character that sharply divides all insects into two groups. There are some insects which have a partial

* *Larva,* plural *larvæ; pupa,* plural *pupæ; imago,* plural *imagines; nymph,* plural *nymphs.*

metamorphosis and which are really intermediate between these two groups; but they are not common and we are unlikely to meet with them. We shall find large and distinct groups of insects which have a metamorphosis, and equally large and distinct groups which have none; every student should know at once whether an insect has or has not a metamorphosis.

Fig. 30.
A wingless mature Cockroach.

Before proceeding to the next section, we may draw attention to a few points.

All perfect insects, *i.e.*, *imagines*, have wings, or should have; there are many exceptions to the rule and in many insects the wings are not fully developed. This is more common in insects which have no metamorphosis than in those which pass through the pupa stage.

Such insects which look immature, can be known as mature if seen coupling. None but imagines, *i.e.*, perfect insects, can couple or reproduce.

On the other hand, any insect with fully developed wings, *i.e.*, with wings with which it can fly, is an imago and will not grow any more. A small flying grasshopper cannot be a young locust or become anything else. A small beetle cannot grow into a large beetle. Whatever its size, a winged insect is full grown and will not do more than lay eggs. This is an absolutely invariable rule.

In later paragraphs, the life history is stated in greater detail and some of the many exceptions to general rules are discussed. In entomology, as in all other branches of biology, the general rules are abundantly proved by their exceptions. There are very few general statements that can be made to which there are not many exceptions. We can say generally that all insects are hatched from eggs, but there are very numerous exceptions; equally we can say generally that mature insects, like other creatures, are of two sexes and that the process of reproduction is dependent upon both sexes; even this statement is not true of all insects. It is necessary to guard against hard-and-fast rules and generalities in dealing with insects; they are valuable as aids to memory and the imagination, inevitable in class rooms and books, but they must be carefully used outside the class room. Nature has no cast-iron rules, and the more we study nature the more we find an infinite variety that laughs at our generalisations. One group shades into another; the habits of one class are linked to those of another by insensible gradations; no two species

are alike in form or habits, so that we must have a clear conception that we are not in a world of clear-cut definitions and distinctions but in one whose first charm lies in its infinite variety.

Eggs.

Insects are not produced spontaneously from plants or from dirt, but arise from eggs laid by the parent insect, or, in rare cases, are born alive. No case is known of insects having been produced in any other way, and in tracing the life of an insect we may commence from the time the parent lays the egg. Insects often appear suddenly in great numbers, and ignorant cultivators believe that they have fallen from the sky or are due to a change of weather or some similar cause. The appearance of an insect in small or large numbers is not a supernatural phenomenon and can only be caused by the parent insect having laid eggs or produced living young in or near that spot at some earlier time; the eggs may not have been seen and may have been there for several months, but in every case if we could go back far enough we could trace them to the parent insects. Reproduction in the insect world is a process similar to that of the higher animals and no more mysterious; it depends upon simple causes which are fully capable of investigation and differs but little from those which bring about reproduction and multiplication in other living creatures.

In almost all cases, the eggs are produced after the mating of the male and female insects; there are a few groups of insects in which males occur rarely or not at all; the females then produce eggs or living young without the co-operation of the males, but this is confined to a small number of insects and in them occurs regularly. If a bred female moth is kept alone in a cage, she may lay eggs, but they are imperfect and do not hatch; an aphis, on the other hand, may produce eggs or living young without any male being present, many successive generations being thus produced without the intervention of any male. In some groups, insects are born alive. In the *aphides* this is the normal process during part of the year, no eggs being formed, but the virgin female producing living young.

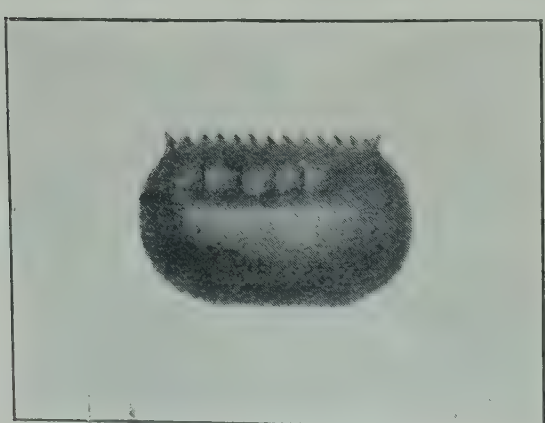

FIG. 31.
Cockroach Egg case. (*Magnified.*)

In some flies, the female carries the fertilised eggs within her body awaiting a suitable opportunity to lay them on sufficiently decayed matter

and these eggs often hatch before they are laid, the fly then depositing living maggots. These phenomena occur rarely in other insects, being exceptions to the almost universal rule that insects hatch from eggs.

Eggs are usually laid where the young will find abundant food and are then abandoned by the parent. Exceptionally the parent cares for and watches over the eggs; this is the case also in social insects, but the eggs are then more usually looked after by special individuals and not by the parent. In most cases the parent dies soon after the completion of egg-laying and the young that hatch live an independent life from the moment they emerge. The beautiful instincts of the digger wasps are perhaps the best instances of maternal care for the young (see page 271).

The number of eggs produced by the individuals of any one species is usually fairly uniform, but varies very much in different species. The large Six-spotted Ground Beetle (fig. 344) produces one large egg at a time and produces only a few in its life; other beetles produce them singly and generally lay only a comparatively small number, but the tortoise beetles,

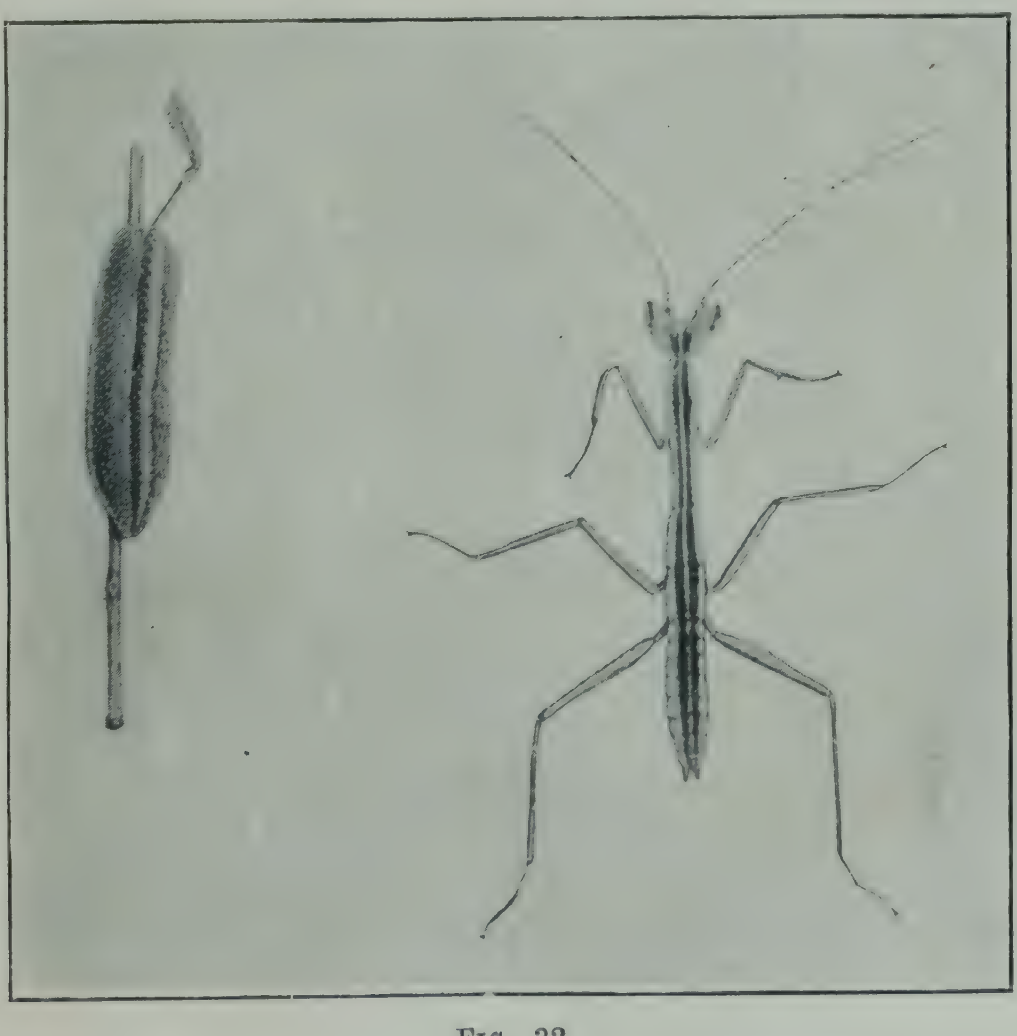

FIG. 32.
Egg case and young of Mantis, the latter magnified.

for instance, produce many and may lay them in beautiful egg cases. Generally beetles' eggs are laid singly and are hard to find. Moths lay many

eggs, usually upwards of one hundred, in clusters or masses. Butterflies lay them singly and in great number. The queen-bee produces a vast number of eggs, laying them singly in the special cells. The locusts and larger grasshoppers lay about one hundred eggs; the smaller grasshoppers some fifty or so. The *Neuroptera* lay many eggs, as do the *Orthoptera*.*

It is probably correct to say that insects which are exposed to enemies lay many eggs to allow for the inevitable destruction of the majority of the young, whilst "safe forms," which live in hiding or are exceptionally well protected from dangers and from enemies, lay a few. The form of the eggs varies very much in different families. Cockroaches lay eggs (fig. 31) in a single case of peculiar form, as do the mantis or praying insects (fig. 32). Stick insects drop, one at a time, peculiar seed-like eggs with lids. Locusts and grasshoppers lay a mass of long oval eggs in the ground and green grasshoppers lay them in the tissues of plants. The eggs of the Lacewing (fig. 332, page 274) resemble grains of rice and are set each on a stalk; many other *Neuroptera* lay masses of eggs in fresh water. The eggs of *Hymenoptera* are small, soft, white bodies, sometimes stalked. Butterflies lay round seed-like eggs, beautifully ribbed; moths lay similar round or flat eggs usually ornamented or marked. The eggs of the common flies are cigar-shaped, deposited singly or in masses. Bugs often lay neat cylindrical eggs with lids, depositing them in batches; the eggs of the Red Cotton Bug are round and yellow, laid in the soil, whilst those of the Dusky Bug are cigar-shaped and laid in the lint of the cotton. With such infinite variety, general statements can be accepted only with great caution.

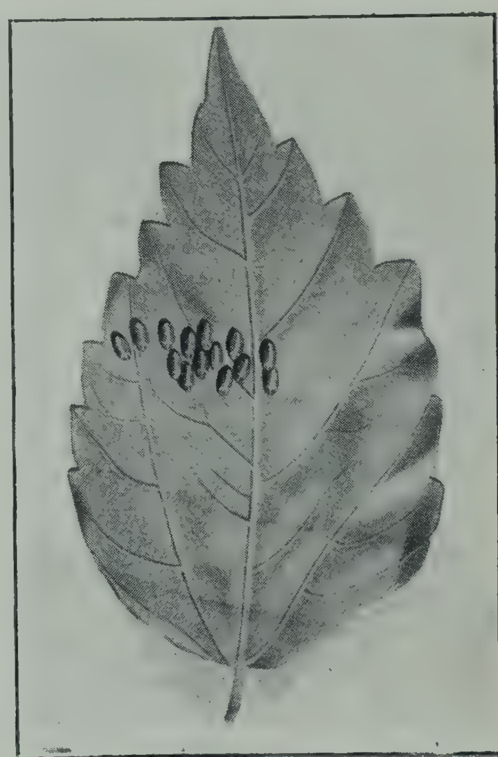

FIG. 33.
The eggs of a Plant Bug on a leaf.

The period during which the egg remains before hatching varies immensely according to species, climatic conditions and other factors. The eggs of butterflies hatch in a few days, as do those of mosquitoes; the eggs of moths hatch very quickly in warm damp weather, but dry cold will delay them. Many insects' eggs remain from October or

* It is necessary to use scientific words to designate groups for which there are no English equivalents. The reader will find the explanation of these words on pages 52—54.—[H. M.-L.]

November to the following rains. The Rice Grasshopper's eggs normally stay in the ground for eight months, but will hatch earlier if kept wet. The degree of moisture and heat have a great influence on this period, and little is yet known of the influence of climatic changes on insect eggs in India.

Larval Life.

When the larva is formed inside, the egg breaks and allows it to emerge. There are special devices for securing the rupture of the egg at the right time, which deserve study. Many caterpillars at once eat the eggshell and then start feeding on their food-plant. As a rule, larvæ develop rapidly with a plentiful supply of food and proper conditions. The temperature and degree of moisture play a great part in the growth of the young larvæ. Feeding is the sole important business and growth is rapid. Moults occur as necessary; caterpillars shed their skins five times as a rule; grasshoppers do so five, six or seven times; the silkworm does so four times. Many bugs do so five times, though the Mealy Bugs and Scale Insects have only two or three moults. Some aquatic insects moult as many as twenty times.

Though the process of moulting is necessary to allow of continued growth, it has also a physiological reason. The chitinous matter thrown off is nitrogenous and it is probable that the nitrogenous waste products of the body are eliminated in this manner; insects have no organs which correspond directly to the kidneys of the higher animals, and a part, if not all, of the nitrogenous waste matter is excreted and periodically shed as chitin.

With each moult the form and colour change slightly or greatly. It must not be taken for granted that the number of evident colour changes and the number of moults are synonymous. We cannot, for instance, collect a great number of the young of a grasshopper, sort them into groups according to size and colour, and then say that each group is the result of one moult; the changes at one moult may be very slight, though far more striking at every other moult. Moulting is not such a regular automatic process that all individuals of a species have actually the same number, and it has been found that grasshoppers from the same batch of eggs take six, seven or eight moults to attain maturity.

Larval life may be very short or very long, depending upon the habits of the insect, as well as on climatic and other conditions. Generally speaking, development is more rapid in hot weather, slower in cold. There is an optimum temperature, the temperature at which development is most natural, which climatic conditions retard or hasten. There is also an optimum degree of humidity, varying for each species. A rise of temperature above a certain point or a fall below a certain point may almost

or entirely suspend vital activities temporarily, and this is determined by the circumstances under which each species lives.

General statements are nearly impossible as they are certain to convey false ideas. Throughout it must be remembered that every species of insects is distinct from every other species in habits, and that every species has as much individuality as each human being, no two species living

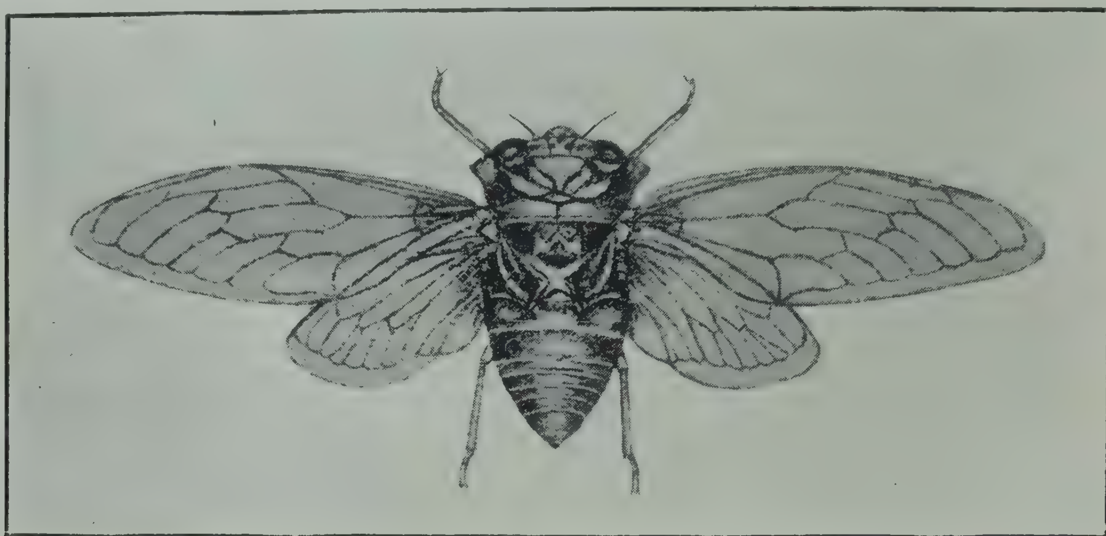

FIG. 34.
Cicada, slightly enlarged.

under identical conditions. We can go much further than this, since even species are not well marked and shade imperceptibly into one another,

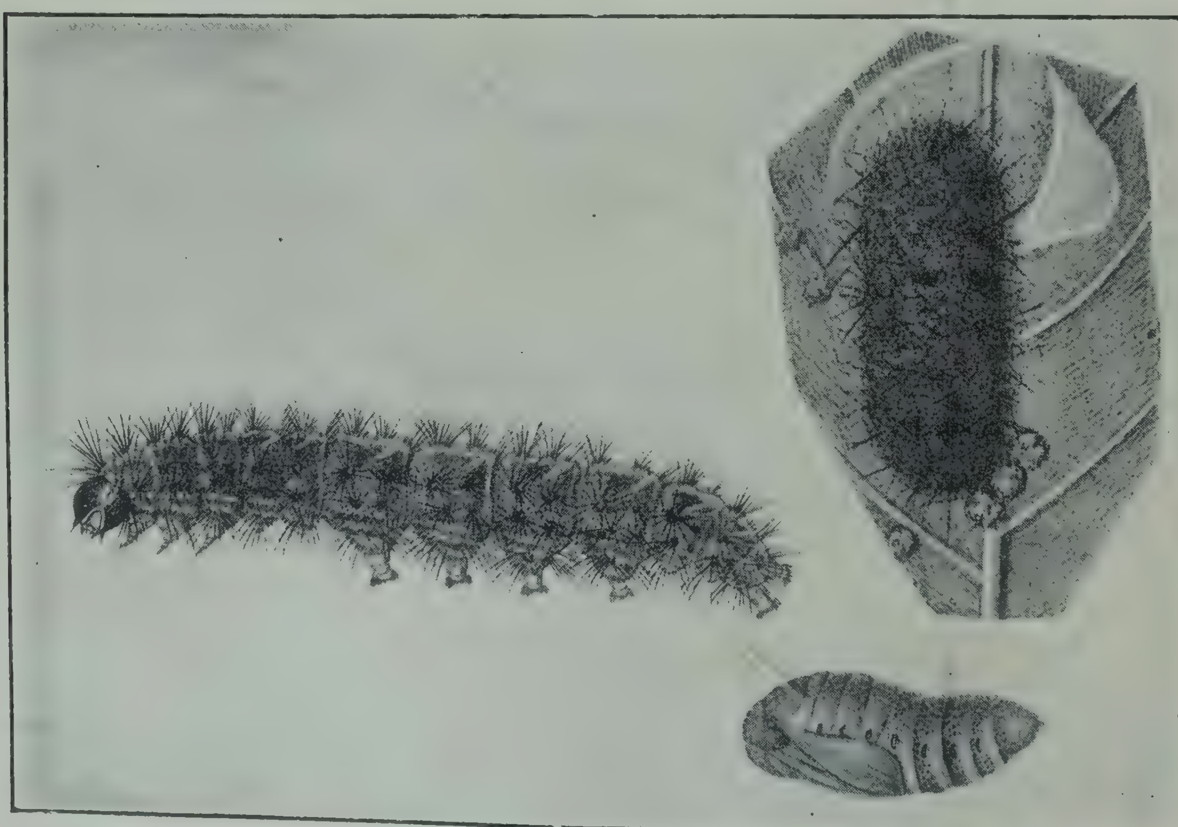

FIG. 35.
A Hairy Caterpillar, and its pupa with the cocoon formed of silk and hairs made by the caterpillar before it becomes a pupa.

FIG. 36.
Weevil, and the case from which it emerges.

but if we are to have clear conceptions of insects' activities, we must think of each species as distinct, so distinct that even we can see the differences.

Subject to this, we may say that cold retards the development and activities of insects; even the cold of the plains sends many insects into a torpid condition, this hibernation lasting for periods that vary according to the lowness of the temperature. Equally, lack of food, dry air, and intense heat, compel the majority of insects to be dormant in some form for some months of the year. This is dealt with subsequently. The periods of larval life may be a few days as in many fly maggots, a few weeks as in most moths, beetles, etc., or a few or many months, as in many beetles. The *Cicadas* probably live far longer as nymphs, one American species living seventeen years underground before becoming an imago.

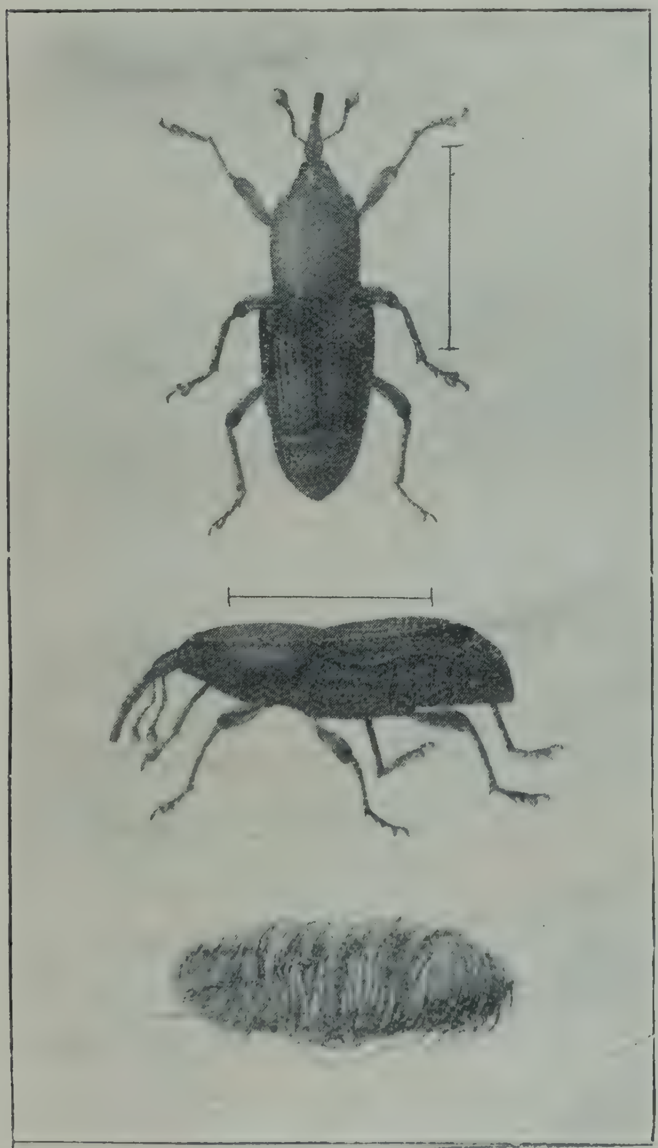

FIG. 37.
The Plantain Weevil, and the case of twisted fibres from which it emerges.

Pupal Life.

The pupa being inactive and helpless is usually concealed or protected from enemies. In *Hymenoptera* it is commonly encased in a silken covering, in a cell, a nest, or in the ground. In *Coleoptera* a silken cocoon is never formed, though approaches

to it are known; the pupa is commonly in the ground in an earthen cell, or in the burrow of the larva or in a tough case on a plant. Many have naked pupæ fastened to plants. The cases they make are of twisted fibres (fig. 37) as in the Palm Weevil (fig. 247), of excrement (fig. 36) as in some leaf beetles and weevils, or of secretion produced by the larva (some weevils). The butterflies have suspended pupæ, fastened to plants, often of peculiar form with resemblances to torn leaves, etc. Moth pupæ are usually in cocoons formed of silk alone (fig. 39) or with hairs (fig. 35) or are found in the ground, on plants in the larval burrows, etc. The silk of commerce is produced from the cocoons of various moths and almost all caterpillars can produce silk throughout their larval life, using it for a variety of purposes. The pupa of *Diptera* is to be found in the habitat of the larva, without covering as a rule. Insects display great ingenuity in the devices they adopt for the protection or covering of the pupa. The pupal period is commonly short, a few days in flies, a week to ten days in many butterflies and moths (unless hibernating), about the same in the known *Hymenoptera* and in some *Coleoptera*. It is however much prolonged in some *Coleoptera* and may be very long in all groups if hibernation is taking place in the pupa, as it often does.

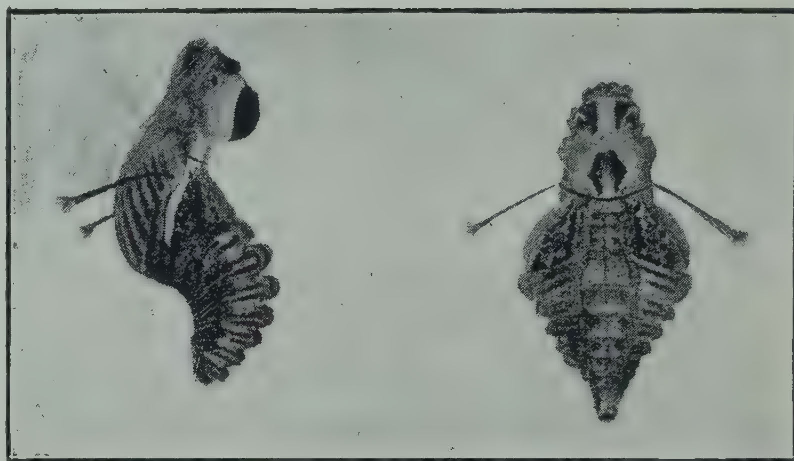

FIG. 38.
Butterfly Chrysalis, showing the thread by which it is fixed to the plant.

In some *Coleoptera*, the imago emerges from the pupa and undergoes a further resting period before leaving its hiding place.

We may here mention the flies which pass through no larval period, but are produced by the parent as full grown larvæ, which at once pupate. The best known of these are the Horse and Cattle Flies (fig. 320, page 265) which live upon the blood of birds and mammals. This abnormal life history is possibly an adaptation to the semi-parasitic life of the imago.

FIG. 39.
Male (above) and female Moth with Cocoon (below).

The life of the imago.

The life of the imago varies much in length in the different groups. Reproduction being the principal business of this period, the imago commonly dies as soon as mating and egg-laying are completed. In the moths and butterflies, courtship, mating and egg-laying may occupy a few days or more rarely a few weeks. The imago has no necessity to provide for her young further than by laying her eggs in a suitable place.

In the *Hymenoptera,* on the other hand, the parent has to provide for her young or actually feed them, as the larval period is one of helplessness during which the grub feeds on the stored up food or is fed by the parent; so also the life of the imago is prolonged until she has fully provided for the new generation or done her share of the work of the nest. Between these two extremes are many shorter or longer imaginal lives. Climatic conditions may determine the length of the life as in the grasshoppers and locusts, the Bombay locust living as imago for nine months until it can lay eggs, whilst allied grasshoppers live as imago for some six weeks only. The May-flies live for very short periods, the long nymphal life being the active period. The dragon-flies, on the other hand, have a long life both as nymphs and imagines. *Coleoptera* live long and can survive long periods when food is scarce and they are waiting until conditions are again favourable for egg-laying. *Hemiptera* and *Diptera* have long lives as imagines, the preliminary stages being proportionately shortened. There is no general rule and it varies from species to species. The activities of an insect are not to be measured by its life in the winged state when it is most apparent to us, but by its whole free life as larva or nymph and as imago. In some the first predominates, in others the latter.

FIG. 40.
Wingless female Wasp.
(*The male is winged.*)

In exceptional cases, both sexes are not equally developed, and in general it is the females which are the least developed. In the "Bag-worms", the female remains as an imperfect pupa and does not become winged or leave the shelter of the larval case, whilst the male becomes winged and seeks the female (fig. 41). In other moths the female may be active but unwinged. In the *Aphides,* the females are frequently unwinged, the males winged. This is the invariable rule in the Scale Insects and Mealy Bugs, in which the females only moult twice and

remain unwinged; whilst the males pass through a transformation and emerge as tiny flying insects with but one pair of wings (fig. 42). These are instances of incomplete development and are not to be confused with the differences between the sexes discussed in a later section.

Hibernation and Broods.

Insects are unable to live and breed continuously throughout the year, except in places with a general uniformity of conditions throughout the whole year. In the plains of India, three causes combine to check the

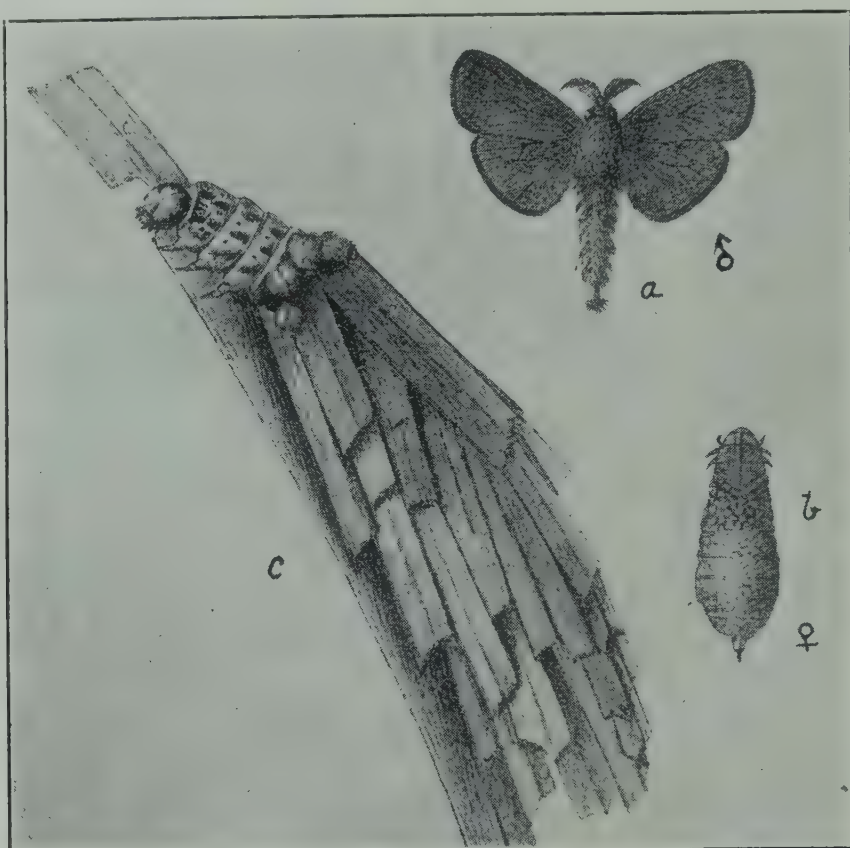

FIG. 41.
The Rice Leaf Bag-worm. a, *male moth;* b, *female adult, an imperfectly developed moth;* c, *caterpillar in case of leaves.*

continuous growth and breeding of insect life; these are cold, excessive dry heat and absence of food.

A great number of insects are inactive in the cold weather and are then said to hibernate; as the temperature falls these insects become torpid, remaining inactive until the temperature rises. Hibernation is not universal; many pests are active in the cold season, attacking the rabi crops; others emerge from hibernation in time to attack the ripening crops. The occurrence and period of hibernation depend largely upon climatic conditions; the temperature does not fall evenly throughout the plains of India, and a species that hibernates in one locality may not do so in another. Much has yet to be learnt of hibernation; few insects are active in the cold weather in dry cold localities; few hibernate in warmer, damper

localities. The rise of temperature after the cold weather does not affect all species alike; one will emerge weeks before another. In rare cases all of one species will emerge with extraordinary unanimity when the temperature rises. It is not uncommon to find enormous numbers of one species of a moth flying in one week, giving place next week to another species which has emerged later.

Hibernation is passed in all stages; it is as yet impossible to give accurate general statements, but one may say that many *Orthoptera* hibernate as eggs, as do one family of butterflies; many *Hymenoptera* and *Coleoptera* hibernate as imagines, others as pupæ. *Lepidoptera* commonly hibernate as pupæ or larvæ, though some butterflies do so as eggs. *Diptera* hibernate as pupæ to some extent, *Hemiptera* as imagines or eggs.

After the cold weather there usually follows a period of dry hot weather prior to the rainy period. Little is known as to the manner in which insects pass through this period. Many species that emerge from

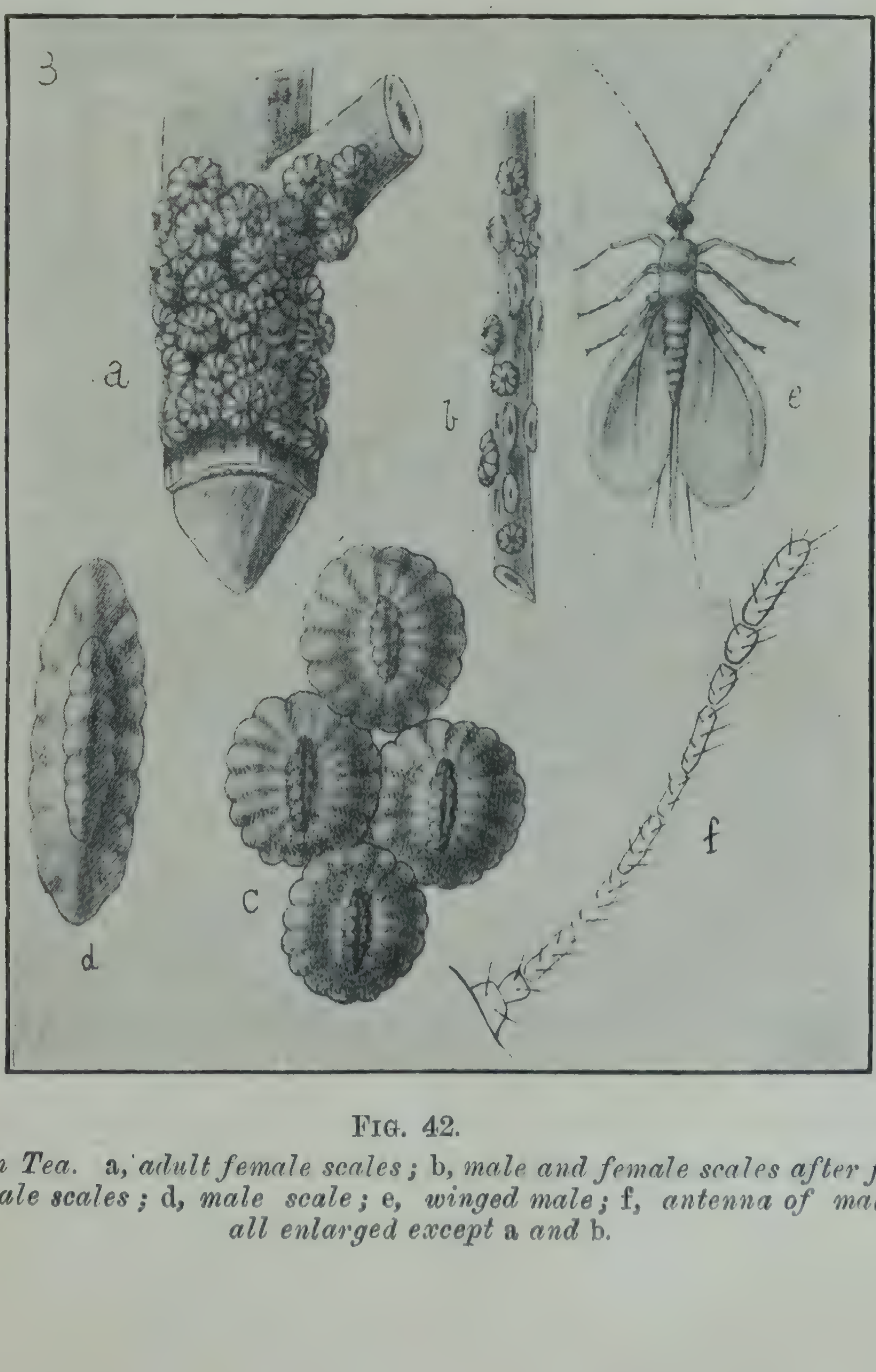

FIG. 42.

Scale Insect on Tea. a, *adult female scales;* b, *male and female scales after first moult;* c, *female scales;* d, *male scale;* e, *winged male;* f, *antenna of male: all enlarged except* a *and* b.

hibernation have one brood between the cold and hot weather and then become torpid, either from absence of food or from the excessively hot and dry conditions. In many cases this period is simply a continuation of the hibernation; the torpidity due in the first place to cold appears to give place to a torpidity due to heat and drought; or we may consider it as due to the absence of food. For many species there is food only during the wet season, so that insects emerging too soon would find no food.

On the other hand, we find insects emerging at the commencement of the hot weather, living as imagines till the rains if food is not available, but laying eggs and producing a new brood if food is available. This is a curiously interesting fact not yet fully understood. For instance, if cotton grows continuously through the cold weather and the hot weather, we find its pests attacking it at the commencement of the hot weather; should the cotton however be dead, we find the same insects apparently living as imagines or still hibernating. When well irrigation is practised in the hot weather, there is food for some insects in the irrigated crops, with the result that these insects are found breeding in March or April; in the same district, where well irrigation is not practised, we find these insects still hibernating or living in concealment as imagines. These are perhaps the exceptional cases, but they are common among the crop-destroying insects.

A larger number of insects appear to continue torpid after the cold weather and until the rains. But again, such is the variety of insect life that general statements are of little use. Many insects are most active in the dry hot weather; the wasps make nests, the first parasites appear, the dung-rolling beetles are seen. Ants, termites and other insects are active. If we turn to crop pests, it is not far from the truth to say that (1) they continue hibernation or (2) they emerge and lay eggs on the crops if available or (3) they live as imagines until the rains. The question of available food-plants is apparently the decisive factor; sugarcane pests are very active in the hot weather, but the conditions of course approximate to those of the rains, there being food and moisture available.

The result of these periods of rest is that for every species there is a definite time during which the imagines emerge and lay eggs. During one week there will be an abundance of a particular moth emerged from hibernation. The period may be longer or shorter, but there is for every species some period, at the commencement of the rains or of the hot weather, when eggs are laid, and shortly after which the first brood of caterpillars emerges. If all the imagines emerged on the same day, we

should get our caterpillars appearing on the same day and a uniform succession of broods throughout the active period. This is not the case, and though the first brood of caterpillars may come at one time, the later ones become irregular. We may take, as an instance, a moth having a life history period from egg to moth of six weeks; if we get the moths out on March the 4th, the eggs are laid by March the 10th, the caterpillars appear, say, by March the 15th, become pupæ about April the 15th and moths about the 22nd April. We find caterpillars again about the beginning of May; later broods of caterpillars would, if food were available, come about the middle of June and the end of August, and the caterpillars of the middle of October would hibernate; there would thus be outbreaks of the caterpillar in the latter half of March, beginning of May, latter half of June, beginning of September and latter half of October; five attacks of this pest in all if food is abundant and all come out together. Actually this rarely if ever occurs, but one can in some cases trace the broods through the year and expect them at their regular dates. In most cases the imagines do not all emerge together and the subsequent irregularity of development of the individuals accounts for the irregularity of the broods. The appearance of large numbers of a particular insect at regular intervals can be accounted for if one traces its history and knows when it emerged from hibernation. We must, however, guard against expecting regular broods; it is often stated that a particular pest has, say, four broods a year; actually it is found throughout a long period, some being late, some early, some at the proper time. The four broods are not regular, and though the insect does breed four times in the year, all do not breed at the same time.

CHAPTER III.

FORM AND COLOUR.

IF we examine an insect, we can possibly deduce from its form, structure and colour many facts as to its probable habits and habitat. The complete structure of an insect, as well as its life history, is intimately correlated with the predominating motives of its life, search for food, escape from enemies, reproduction of the species.

In all insects the modifications of form and colour which are correlated with sex and reproduction appear only in the imago stage. Larvæ are of no sex and even the larger nymphs of the *Orthoptera* display only minor sexual differences, the sexual characters not being matured until the final moult. In the higher insects the search for food is confined to the larval stage, not wholly but very largely. We may regard the division of the life of an insect into distinct periods, in one of which the search for food is the principal business, in the other reproduction, as a valuable adaptation, which may account for the success of the insect group over others.

In nearly all insects the necessity of special devices for offence or defence lasts throughout the entire life. The exceptions are the insects which live hidden, such as the borers; with these exceptions, every insect must be protected from foes, and in all stages we find that there are numberless special contrivances for securing immunity.

It is impossible to discuss fully the varieties of form and colour found in insects. There is a meaning in the colour scheme, the details of the structure, the general form and appearance of every species, which we could find if we were fully acquainted with its habits. We are only slightly acquainted with the lives of any insects, and most live in ways totally unknown to us. It is possible only to outline a few generalities, principles that extend over large groups of insects and give us a clue to the method of understanding the significance of form and colour in insects.

Size.

The general conception of the size of an insect is perhaps of something about as large as a bean or larger. The majority of species are, however, less than one quarter of an inch long; it is misleading to judge from our observation of insects, since the larger ones catch the eye, are more easily studied and far more easily preserved, whilst the smaller insects escape notice and are passed by.

It is not unreasonable to suppose that a smaller insect requiring less food and able to live long periods on little nourishment thrives where a larger insect could not. Probably it can reproduce more rapidly, it offers less inducement to enemies, and on the whole may be more successful. These considerations probably determine the limit of size and

FIG. 43.
The Oleander Hawk Moth: one of the swiftest-flying of the large moths of India.

the average is far lower than is generally supposed. Large insects are rarely so injurious or plentiful as small ones. Locusts of course are an exception. The very large ones cannot perhaps multiply sufficiently fast,

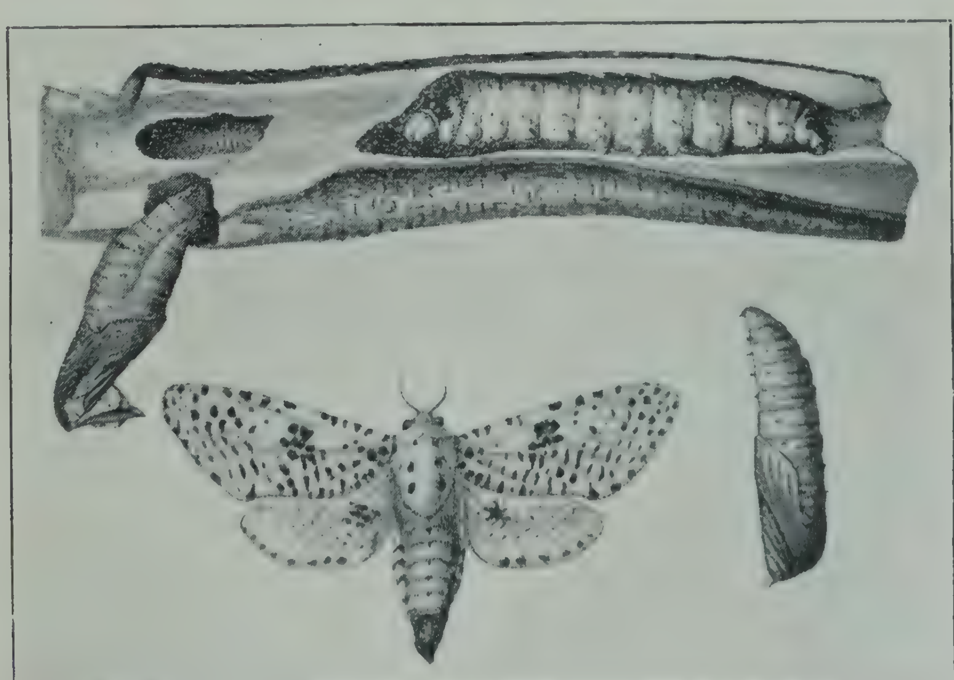

FIG. 44.
The Red Borer of Coffee: caterpillar; pupa, as it wriggles out of the branch; moth.

whilst the small forms have an enormously rapid power of multiplication. In any one species the size is usually constant, but is not a character that can be used to discriminate species. Some species are very variable in size, and males are frequently smaller than females.

Form.

The fact that an insect's form is correlated with its habitat and by the necessities of procuring food is abundantly manifest. Insects in general are somewhat cylindrical, a form that allows of twisting and flexible movements. This persists in flying insects (fig. 43), as offering less resistance to the air and is also well seen in most larvæ. Boring insects are extra-cylindrical, as it were, fitting tightly in the tubular burrows they make or, as in the beetle grubs, having a special cushion-like projection that fits the burrow tightly and facilitates locomotion (fig. 88).

FIG. 45.
Common Cockroach.

Many insects are flattened; bark beetles and similar insects that find food between the bark and the wood are often flat, to the extreme of being leaf-like. Ground beetles, cockroaches (fig. 45) and other insects that live on the ground, hide under stones, and run fast, are usually flattened. So too are some caterpillars (fig. 47) that cling tightly to the leaves of plants, and leaf-miners which find their food between the upper and lower epidermis of a leaf. The tortoise beetles are flat and can cling very tightly to a smooth leaf after the manner of a limpet on a rock. The praying mantises are often formed like a grass stem, and lurk in the grass in the hope of unwary insects mistaking them for a grass stem and so getting within their reach. Others resemble dry sticks and live on dry bushes. The green grasshoppers (fig. 29) for a similar reason are formed so as to suggest a green leaf and deceive butterflies. Maggots that live in decaying matter are smooth and worm-like, with

FIG. 46.
The Bug; an example of a flat insect. (Magnified.)

specially large stigmata at the tail so that the maggot may lie embedded in liquid and still obtain air.

These modifications are necessitated by the search for food; others

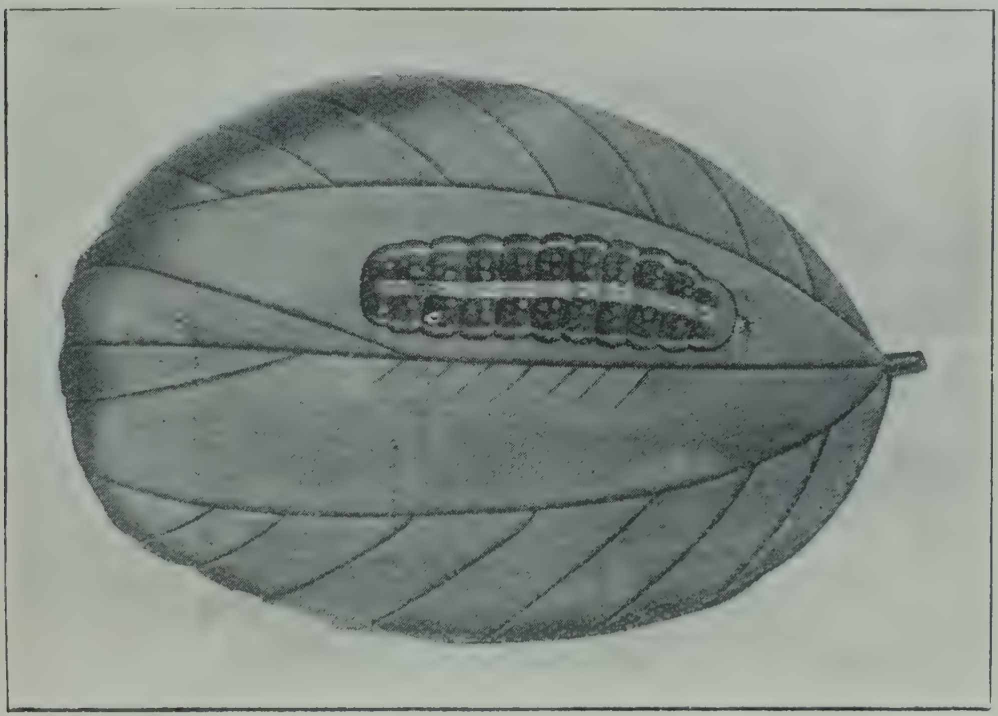

FIG. 47.
Slug Caterpillar, specially adapted to cling tightly to leaf.

are of use in conferring immunity from foes. "*Cryptic form*" is most

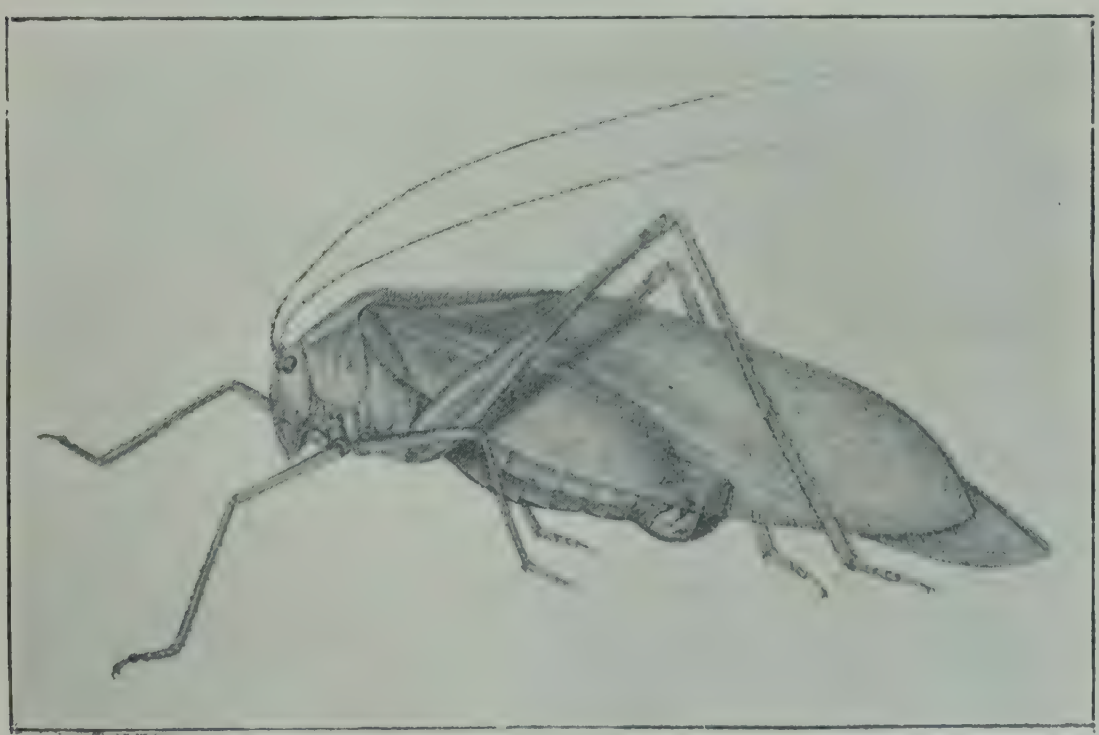

FIG. 48.
Leaf Insect.

commonly associated with cryptic colouring and is seen, for instance, in the stick insect whose long and slender body is formed and coloured to

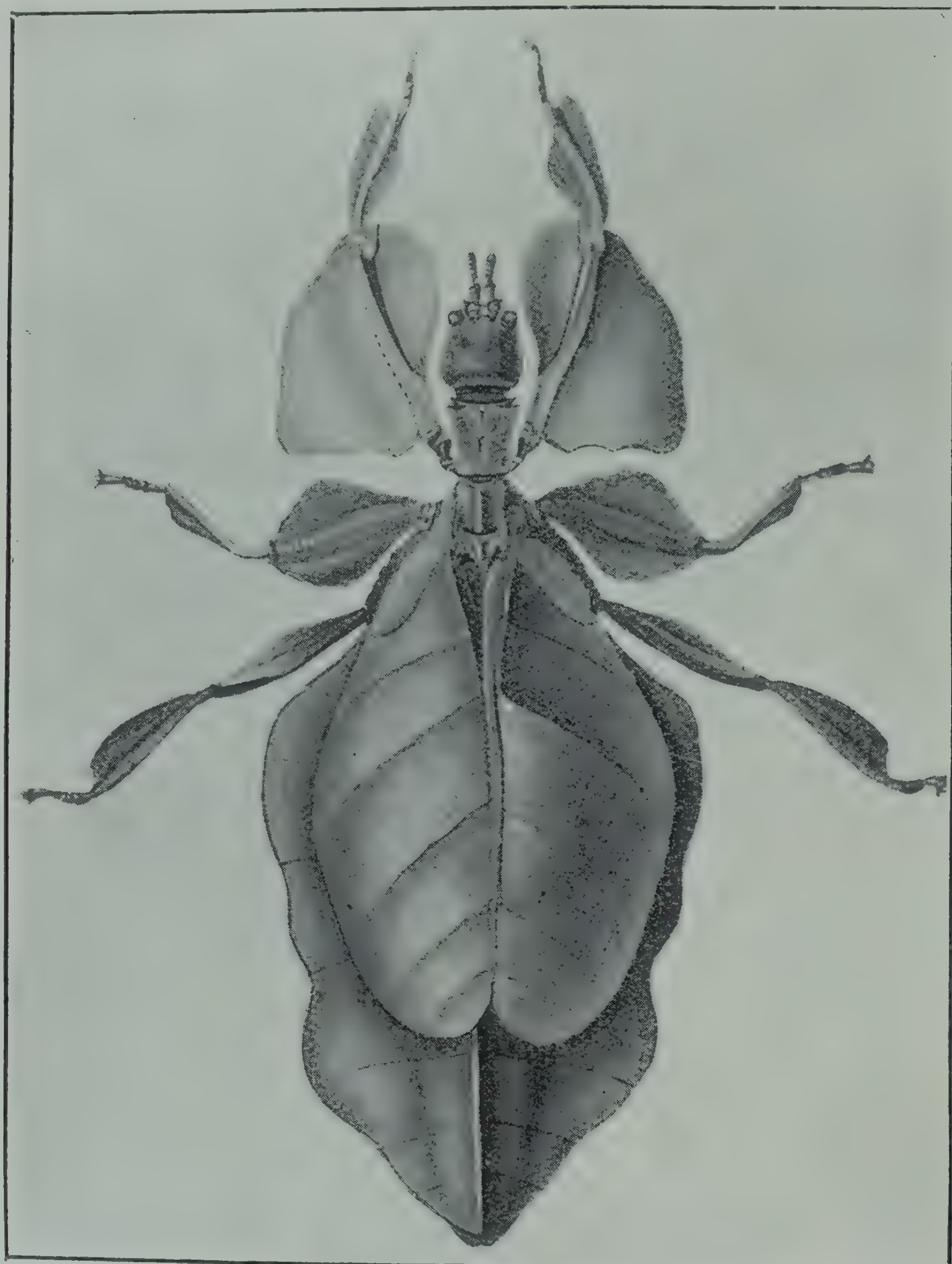

FIG. 49.
Leaf Insect.

resemble the twigs amongst which it lives; we suppose this to be a device to hide the insect from birds. So too in the Leaf Insect (fig. 49) which bears an extraordinary resemblance to a bunch of green leaves. The intensely hard spines found on some beetles and bugs, the thick coating of hairs (fig. 50), the very thick hard masses of chitin, are believed to make insects distasteful to birds and possibly to predaceous

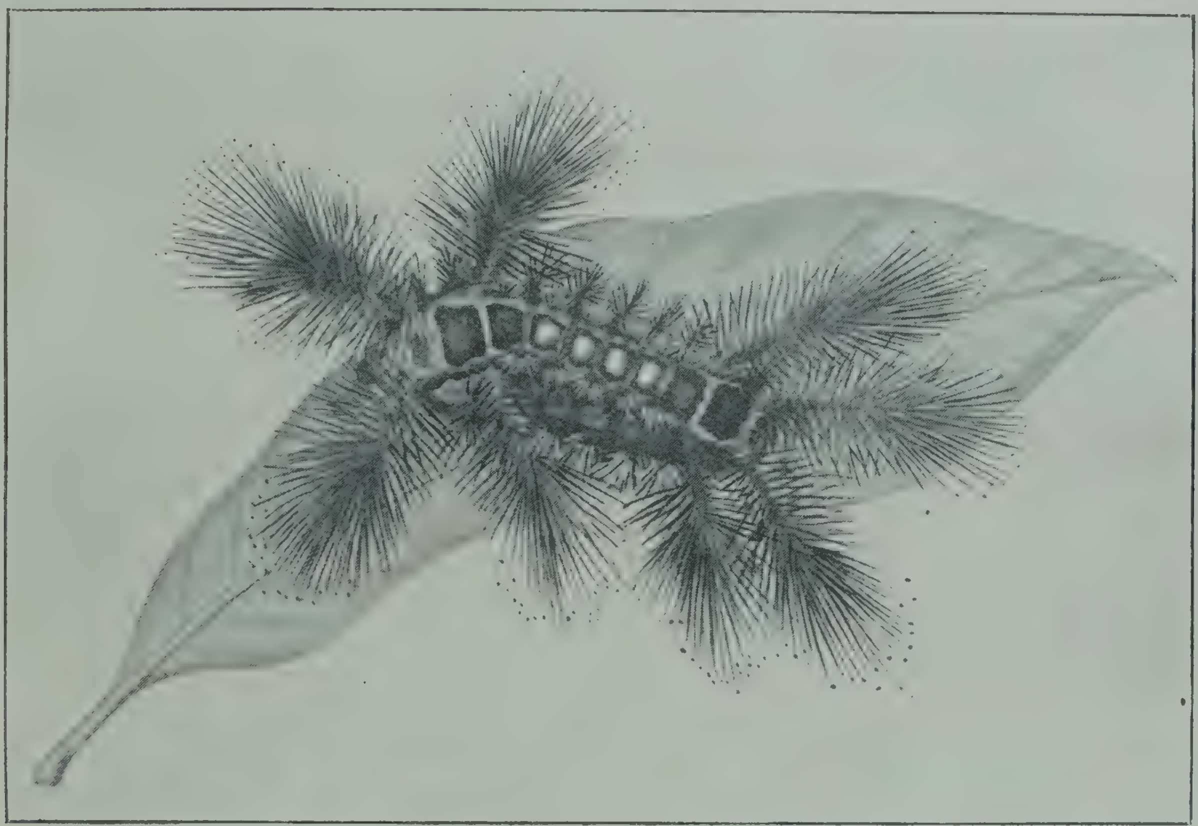

FIG. 50.
Spiny Caterpillar, the spines poisonous.

insects. The unpleasant odour of bugs is certainly a protective device; so too are the bad tasting oils of the blister beetles and ladybird beetles. Some beetle grubs cover themselves in their own excrement, others carry their cast skin. The Lace-wing grub carries a pile of the cast skins of its victims. Stings are probably protective, though birds and lizards eat bees. An unpleasant taste is also probably protective and is associated with the scheme of colouring known as warning colouration.

Sex also profoundly modifies the structure of insects. The internal organisation is of course totally distinct and there are commonly external organs which readily reveal the sex (fig. 52).

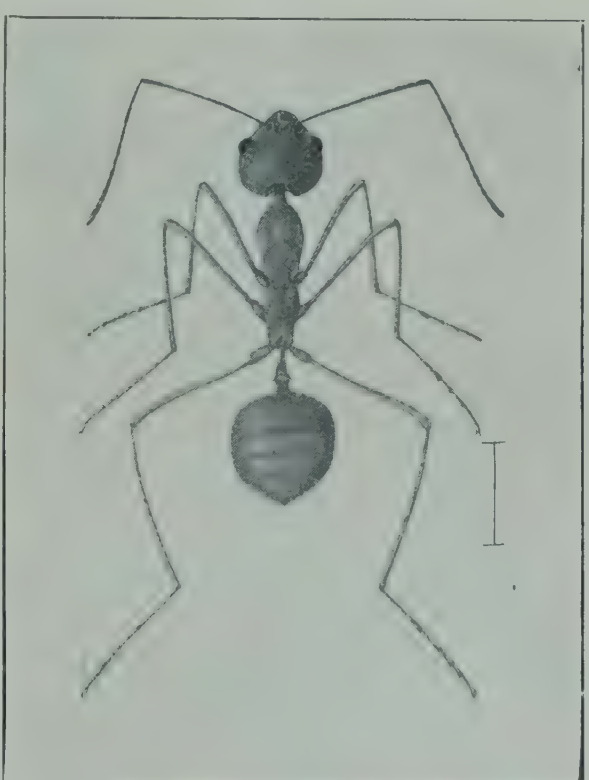

FIG. 51.
The Red Ant, a wingless worker, mature but sexless; their pungent flavour and keen bite is their protection.

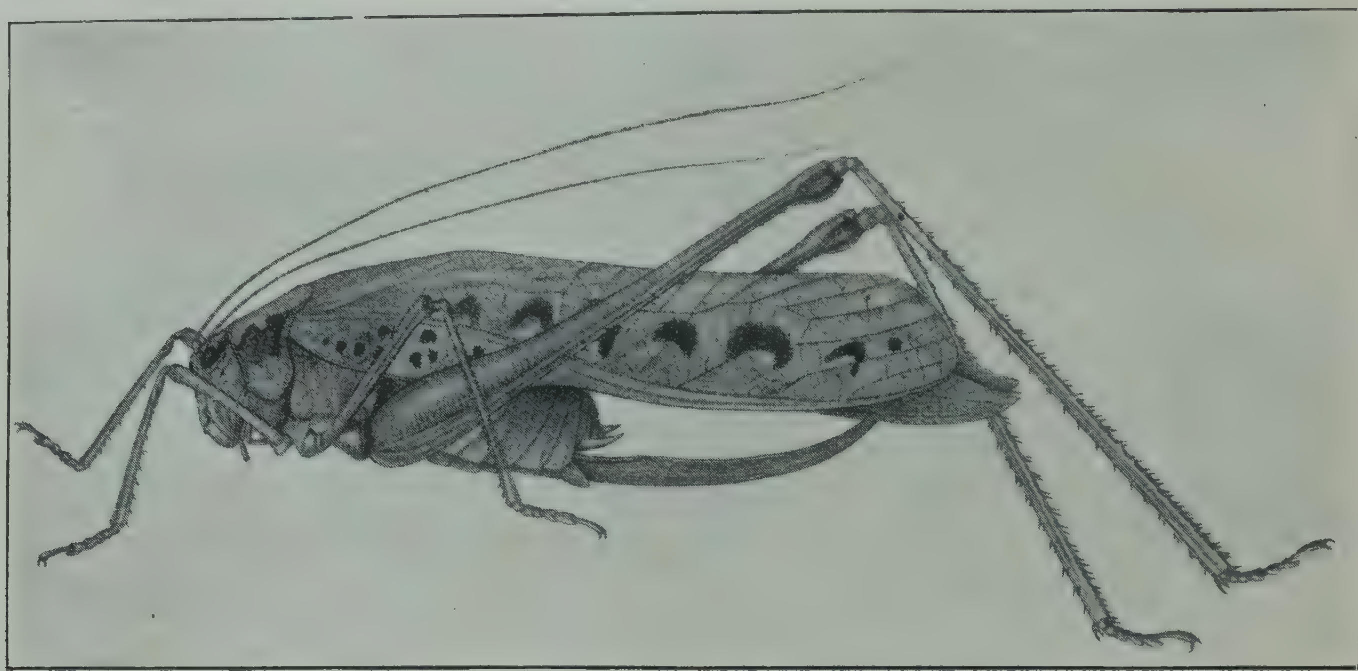

FIG. 52.
Female Long-horned Grasshopper, to show the sword-like Ovipositor.

In general where there is a diversity of sex, the male is the smaller (fig. 53); both sexes are frequently similar in size and external characters, the sex being determined only by dissection. In many *Orthoptera* the males are smaller and differently coloured, in rare cases being very unlike the female in general appearance. The male stick insects are often winged when the females are unwinged.

FIG. 53.
Male and Female Moth, the smaller male above.

There is little or no difference between the sexes in *Neuroptera*.

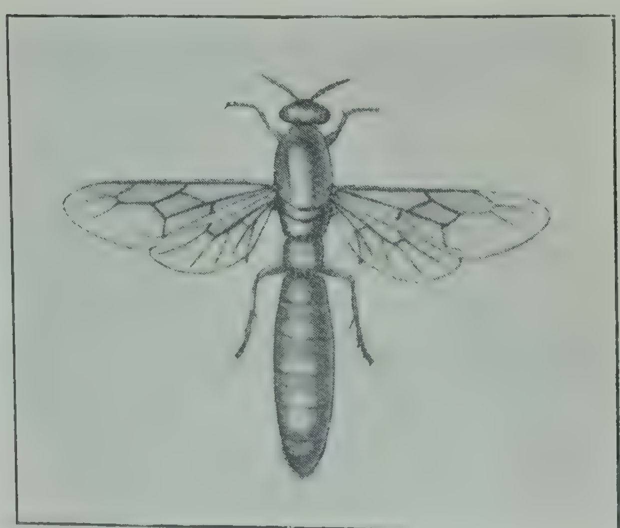

FIG. 54.
Male Ant.

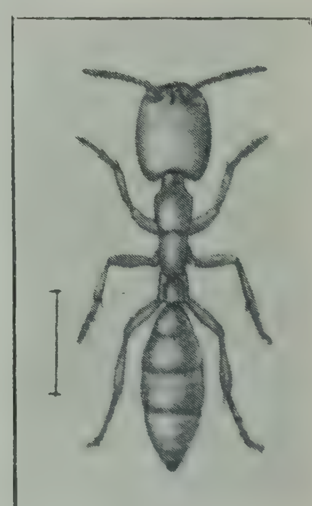

FIG. 55.
Worker Ant. (Magnified.)

In many *Hymenoptera* the sexes are very distinct. In the social insects this is carried to a great extreme and we find only a small number of individuals with reproductive organs, the majority being sexless workers (figs. 51 and 55). In solitary bees and wasps, there is a distinct male, and in one family the female is wingless, the male winged (fig. 40). Beetles display little external difference; exceptionally the male bears horns (fig. 56); in some wood-boring beetles the male is wingless (fig. 86).

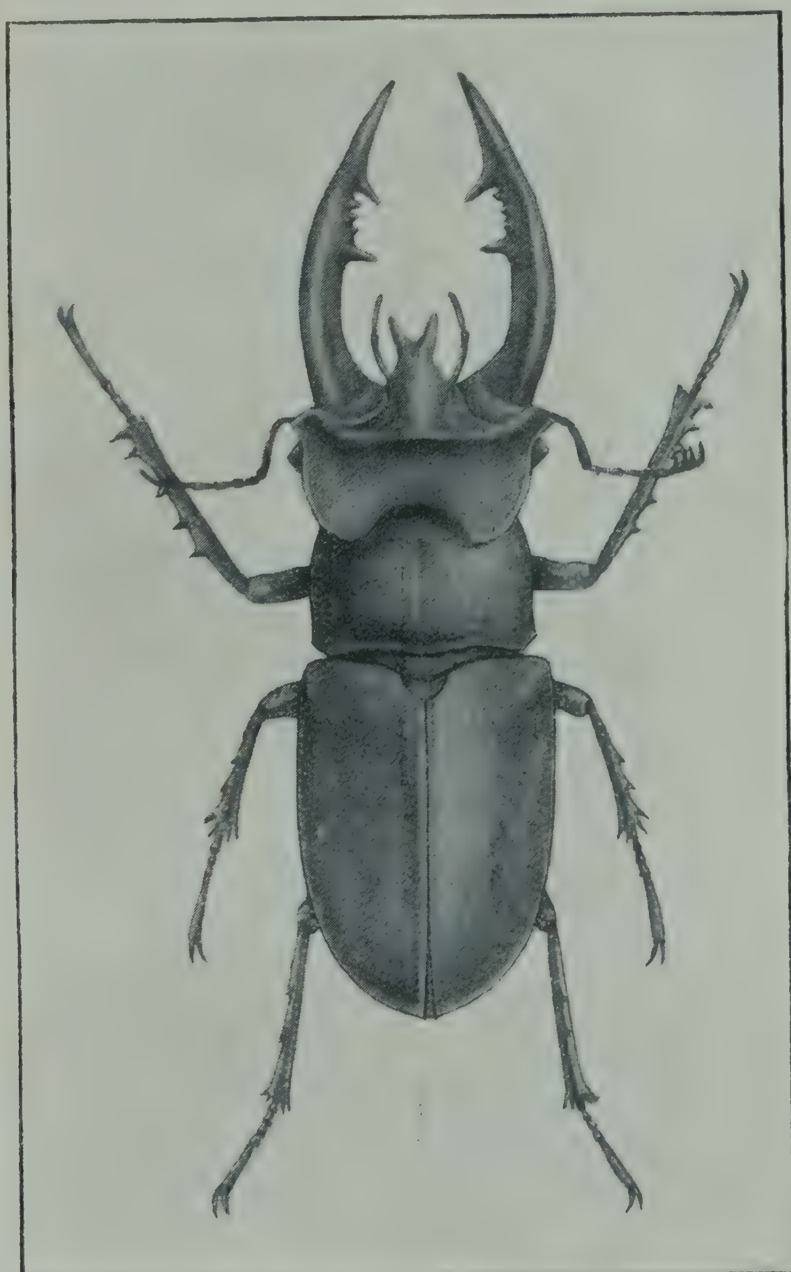

FIG. 56.
Male Stag Beetle.

Butterflies display great sexual differences in colour, form, etc.; we reproduce one species (figs. 58-59) in which they are very strikingly different. Moths rarely display great or noticeable differences, more often small

distinctions only. Females are in some cases wingless. In flies there are seldom striking differences; male mosquitoes have large feathery antennæ, females smaller ones (fig. 60). Bugs are rarely distinguishable, but some of the predaceous species have clearly distinct sexes. In *Aphides*, males are often absent; in Mealy Bugs and Scale Insects, the male alone is winged, the female wingless and degraded.

Fig. 57.
Female Stag Beetle.

Male insects commonly produce sounds or songs. Grasshoppers chirp by rubbing the hind leg along the front wing; green grasshoppers have a powerful sound-producing apparatus at the base of the wings. Crickets produce a shrill loud noise. All of these insects also have ears with which to hear the music they produce. Beetles have a very great diversity of apparatus for producing sounds. The best known noisy insects are the *Cicadas* which live in forests; they are possessed

Fig. 58.
Male Butterfly.

FIG. 59.
Female Butterfly.

of a complicated sound organ at the base of the abdomen, with which they produce a peculiarly piercing and shrill noise. A few bugs can

FIG. 60.
A Mosquito, male above, female below. (Magnified.)

sing or chirp. Song is mainly concerned with sex and is possibly one of the few means by which the male captivates or pleases the female; song may also be connected with the fact that the male is not burdened with the chief care of life, the satisfactory deposition of the eggs, and so utilizes his superfluous energy in song. Another manifestation of sexual difference may perhaps be found in the luminous insects.

Colour.

All insects which live in the open air are coloured in a more or less complex manner; the scheme of colouring is in many species variable within certain limits, but generally is uniform and fixed in all individuals of one or both sexes of the same species. These colour schemes are evidently important to the welfare of the insect, and attempts have been made to elucidate the general principles that underlie them; no two species have precisely the same form and colour, but large numbers have a similar colour scheme, differing in detail in each species but agreeing in the general effect.

We have seen above that some insects, such as stick insects, are so

Fig. 61.
Moth on Bark of Tree. An instance of cryptic marking.

formed as to closely resemble their surroundings and so escape notice; this is associated with colouring, and the conjunction of cryptic form

and colouring may render a large insect indistinguishable from its surroundings. Leaf insects are coloured like a leaf, which may be green or dry. Many moths (fig. 61) sit with expanded wings and the colour scheme blends with the bark on which they sit so well that the moth escapes notice. Others sit with folded wings and exactly resemble bark; their lower wings are then hidden and may be brightly coloured. Grasshoppers commonly have cryptic colouring, some being dry-grass colour, others green-grass colour, and so on. Grasshoppers that live in the fields and sit on the ground are earth colour (fig. 62) and have roughened backs like a lump of soil.

FIG. 62.
Surface Grasshopper.

Cryptic colouring is very common, usually combined with cryptic form; it may occur in two different colour schemes in the life of an insect, the change occurring when the changed surroundings make it necessary. Thus a young grasshopper that lives in green grass is green, but becomes dry-grass colour when the grass ripens and the insect becomes full grown. A caterpillar that sits on a leafy tree is green, perhaps so long as it remains there; when it has to crawl down the trunk to reach the ground and pupate, it becomes brown as the green would make it conspicuous against the bark of the tree. Those larvæ which live in nests or other hidden spots change but little at each moult unless their habits require a change. The changes may be small and imperceptible or very marked, and bear a close relation to the differing habits of the young and the old insect. The same is true of the nymphs of the *Orthoptera* and *Hemiptera*. With every moult there are distinct changes not due alone to the gradual development of the wings and other imaginal characters, but to changes of colour and form necessitated by changing environment. The very young nymphs of a grasshopper, for instance, which live concealed in grass require a very different colouring from the half-grown insect which leaps actively about in the open; the colour therefore changes at each moult, adapting the insect to its increased activities and gradually giving place to the colour scheme of

the imago, which usually commences to appear in the last moult but one or two. There are countless instances of these changes and we may constantly see instances of cryptic colouring.

On the other hand, we find some insects very vividly and brightly coloured, so that they stand out strongly against their surroundings.

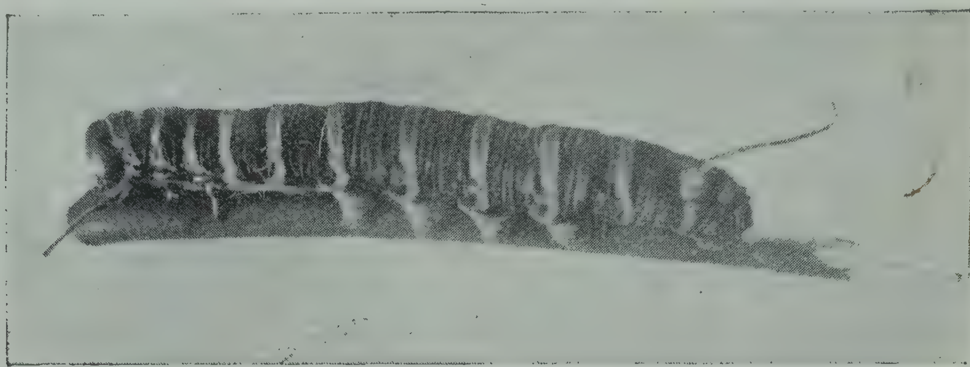

FIG. 63.
The South American Caterpillar which suggested "warning colouration"; the light bands are bright yellow, the feet and process red.

These insects are usually distasteful to birds and predaceous insects either from their taste, odour, or the oils they excrete. Their striking colouration is accordingly supposed to be "warning", *i.e.*, warns the birds that the insect is unpleasant. A young bird eating such an insect associates the bright colours with the unpleasant taste; it then refuses to eat similarly coloured insects and warningly coloured insects escape. There are many insects supposed to be warningly coloured; red, orange or yellow with black are common warning colours. Most bees and wasps, ladybird beetles, some blister beetles, and some butterflies are so coloured.

FIG. 64.
Moth of the previous Caterpillar, coloured cryptically in grey and black.

Dragon flies are often brilliant, with red, blue, yellow, green and other vivid colours associated with black. A few grasshoppers are very vivid. Warning colouring is very common. It is found that many insects exactly copy the markings of such warningly coloured insects ; the former

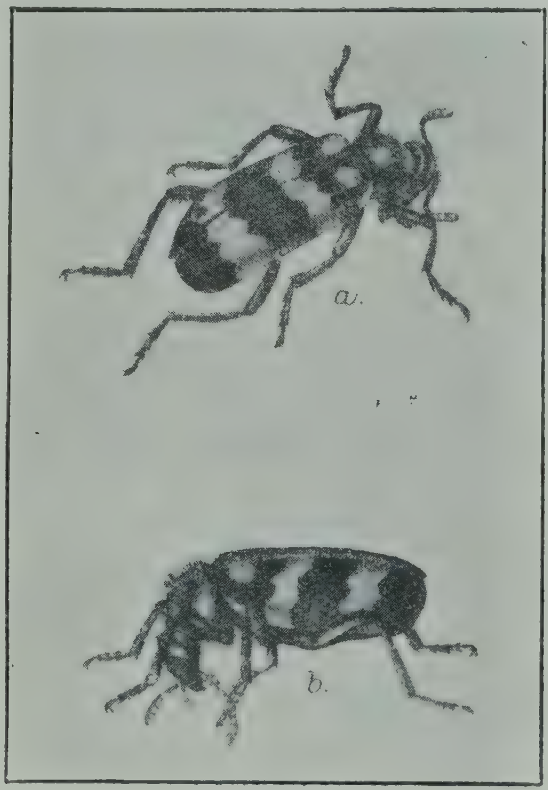

FIG. 65.
Warningly coloured Beetle.

are not distasteful, have no unpleasant taste or smell, but escape because they look like nasty butterflies or beetles. This is known as *Batesian mimicry,* after its discoverer. Many Danaid butterflies

FIG. 66.
A Wasp, protected by its sting and warningly coloured.

FIG. 67.
A Fly, harmless and edible, which mimics the Wasp.

are warningly coloured ; other butterflies, not of this group, but living in the same locality, exactly mimic the Danaid in form and colour ; they look closely alike and only careful examination shows that

the latter are different in fundamental structure. The edible mimic escapes through its resemblance to a distasteful insect. This form of mimicry is common. Edible butterflies mimic nasty ones; moths mimic butterflies; flies mimic moths; flies also mimic bees or wasps; there are abundant instances which can be cited among Indian insects (figs. 66-68).

Another form of mimicry occurs when we find in one locality a large number of insects with a general warning scheme of colour, say black and yellow. Among all these insects having a similar colour scheme some are genuinely nasty, protected by unpleasant taste, bad scents, poisonous bite, sting, etc., so that birds will not willingly eat them. Others are not unpleasant, but pretend to be so by "adopting" the same scheme of colouring. This is called *Mullerian mimicry* and is also common. It must not be thought that an insect can change its colour voluntarily; the colour of insects is fixed and all of a species are coloured much alike; but it is believed that in the evolution of insects, the species "adopted" or gradually acquired colour schemes, and so the warningly coloured insects arose first and other species later. If we disbelieve evolution, we may say that the mimics were made like the warningly coloured insects, and any misconception due to the deficiencies of the terms used will be avoided. A few insects are so coloured and formed as to resemble unpleasant substances; thus the larvæ of the citrus butterflies are not unlike the excrement of a bird and feed on the leaves in such an attitude as to assist the resemblance (fig. 195).

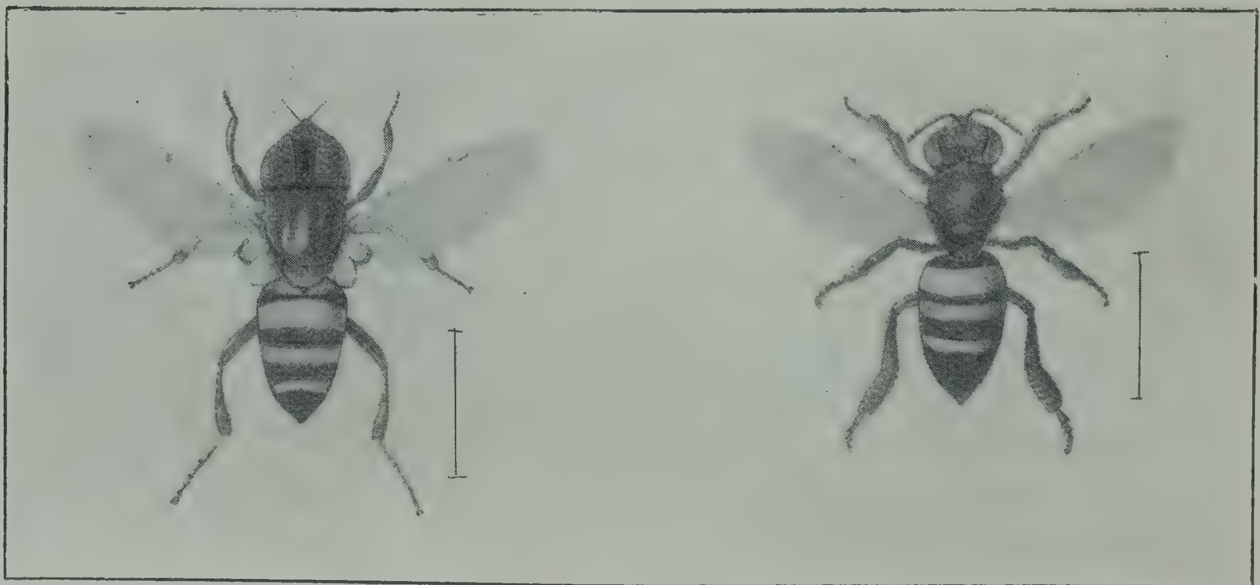

FIG. 68.
A common Fly (left) which mimics the common Bee (right) and so escapes its foes. (Magnified.)

Deceptive colouring is very common; it is apparently designed to deceive birds and is useful when an insect is in flight. The Leaf Butterfly is an instance; the upper wings are brightly coloured and the insect in

flight is conspicuous; it flies along and suddenly settles with wings

Fig. 69.
The Hooded Grasshopper, which combines protection due to the hard sharp hood with cryptic and deceptive colouring.

folded, exactly resembling a dead leaf; the suddenness with which the bright colours of the upper surface vanish is extremely deceptive and makes it very difficult to distinguish the butterfly. Grasshoppers have the same colouring, the lower wings being often brilliant and very noticeable when the insect flies; it then suddenly settles with folded wings and the colours exactly blend with the dry grass; it is impossible to see where it is and we may conjecture that a bird is also deceived. This is a common scheme of colour and is usually shown by the upper wings being cryptic, the lower very bright and conspicuous. Moths, grasshoppers and other cryptically coloured insects are the best instances.

Many butterflies have beautiful, diverse colouring, which does not fall into any of the above schemes. Some have very conspicuous marks on the hind angle of the wings or on the front wings; these are supposed to mislead a bird which attempts to seize them, the bird snatching at the conspicuous spot on the wing and so

Fig. 70.
A Butterfly with eye spots to deceive birds.

missing the butterfly which loses a part of its wing but escapes alive. This may seem to be a fantastic explanation, but it is borne out by good evidence.

Other butterflies are perhaps coloured in rough imitation of their surroundings as seen from above, *i.e.*, their colouring blends with the light and shade of vegetation when they are looked at from above as a bird looks at them. We cannot be certain of this since we see them from about their own level, but the explanation of the colouring of many butterflies is probably to be found in this. A few insects have apparently a scheme of colouring that is meant to terrify an enemy or frighten it away. Such are the Hawk Moth Caterpillars, which when alarmed suddenly expose large eye-like spots and look like a ferocious snake; others simply look bizarre and fearful, if we can judge from what we imagine a bird feels when he encounters one. Many caterpillars have such devices, coloured spots and stripes, brightly coloured filaments, waving hair tassels and the like.

These are the principal colour schemes found in insects, but still we are ignorant of the significance or value of the colouring of many insects. Ground beetles are commonly black or very dark coloured, perhaps because they live in hiding. Many are white, especially those which come out in the dusk, and this may facilitate courtship and mating. Colouring is possibly not determined by utility in every case, but is simply for beauty, and the general effect of insect colouring is, from man's point of view, chiefly one of beauty. Possibly this is the case also from the insect's point of view, and though necessity is considered, the whole scheme may be primarily for beauty.

Fig. 71.
Lacewing Bugs; their minute size is shown by the hair line.
(*No meaning except pure beauty can be assigned to their delicate ornamentation.*)

MAX
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We may remember that the colour schemes of the very great majority of insects have to us no meaning. The few that exhibit Batesian or Mullerian mimicry or are warningly coloured, are a very small part even of known insects. The ordinary insect picked up at haphazard does not fall into any class; we can see sometimes that the colouring perhaps blends in several schemes, cryptic, warning, sexual and the like; but we cannot judge in the least of the real value or significance of the colour schemes of nine-tenths of the known insects. It would not be surprising if a growing knowledge produced a far profounder and truer interpretation of colour in insects, more in accordance with the real needs and necessities of insect life.

CHAPTER IV.

CLASSIFICATION AND NOMENCLATURE.

A VERY large number of insects are known to occur in India as in other tropical countries which it is no easy matter to classify. Insects are primarily divided into nine orders, two of which are of little importance and rarely met with. The seven large orders are easily distinguished according to the structure of the wings and mouth-parts and by the life history. A knowledge of classification is necessary to enable one to place every insect into its order; one then knows whether it may be expected to have a metamorphosis or not, and one has a clue to its probable habits and nearest allies. It is not necessary in these pages to go further than the principal orders. The final classification into sub-families, tribes, genera and species is a matter of special study and is best left to those who work in museums and study only the dead insect. The student will require also a knowledge of the chief families of each order, but this point cannot be entered upon here. The seven principal orders are most conveniently known by their scientific names, since there are not in all cases English equivalents. The following are the orders with their distinguishing characters :—

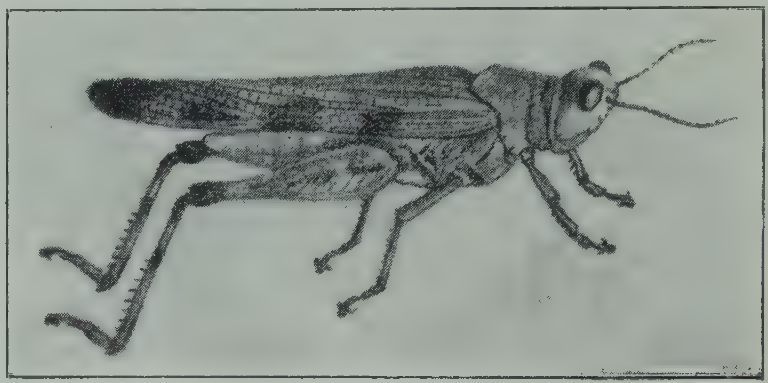

FIG. 72.
Orthopterous Insect.

Orthoptera (*orthos* = straight; *ptera* = wings). Cockroaches, leaf and stick insects, locusts, grasshoppers and crickets. The first pair of wings are narrow, with straight edges, the second pair large, folding up under the first. Biting mouth-parts. No metamorphosis.

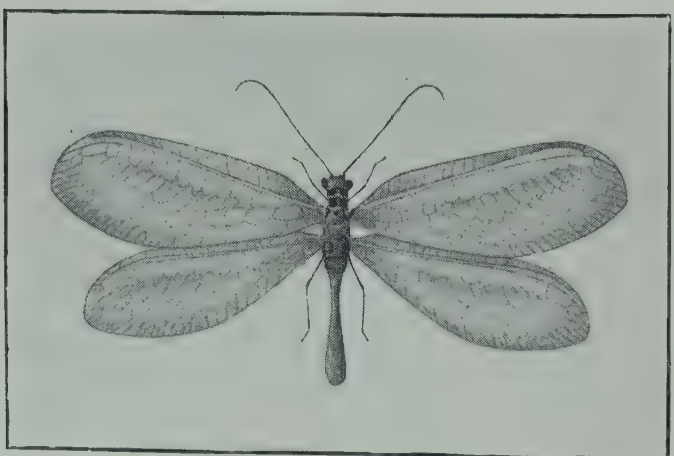

FIG. 73.
Neuropterous Insect.

This order is easy to recognise by their thick, coloured

upper wings, which do not fit tightly to the body but project beyond the end of the abdomen (fig. 72).

Neuroptera (*neuro* = nerve; *ptera* = wings). Termites, ant-lions, dragon-flies, may-flies, etc.

The wings are large with many veins (nerves) forming a network. Biting mouth-parts. A metamorphosis in some, not in others.

FIG. 74.
Hymenopterous Insect.

FIG. 75.
Hymenopterous Insect.

Hymenoptera (*hymen* = membrane; *ptera* = wings). Bees, wasps, ants, etc.

The wings are small, transparent, with few veins. Mouth-parts biting and lapping. A metamorphosis, the larva being usually a helpless grub.

FIG. 76.
Coleopterous Insect.

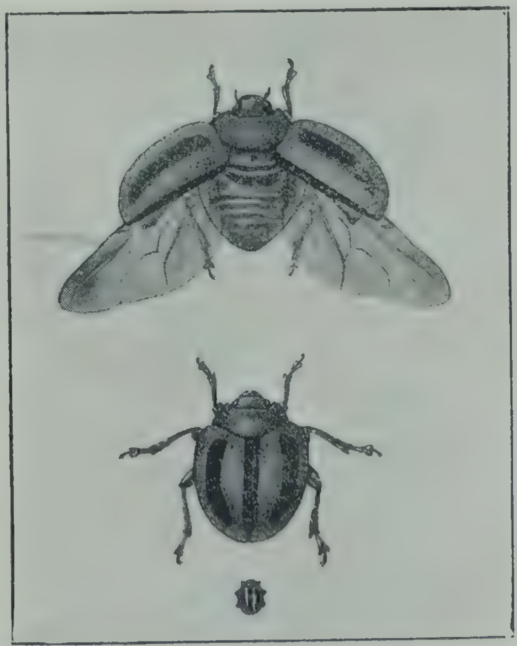

FIG. 77.
Coleopterous Insect to show lower wings.

Coleoptera (*coleon* = a sheath; *ptera* = wings). Beetles.

The first pair of wings are thickened, fit tightly to the body and make a sheath for the large folded lower wings. Biting mouth-parts. A metamorphosis, the larva being an active grub.

These are easy to recognise, the hard upper wings meeting in a straight line over the back.

Lepidoptera (*lepis* = a scale ; *ptera* = wings). Butterflies and moths.

The wings are large, clothed in fine scales.

The imago has a suctorial proboscis.

FIG. 78.
Lepidopterous Insect.

A metamorphosis, the larva being a caterpillar with biting mouth-parts.

Diptera (*di*=two ; *ptera* =wings). Flies, mosquitoes, etc.

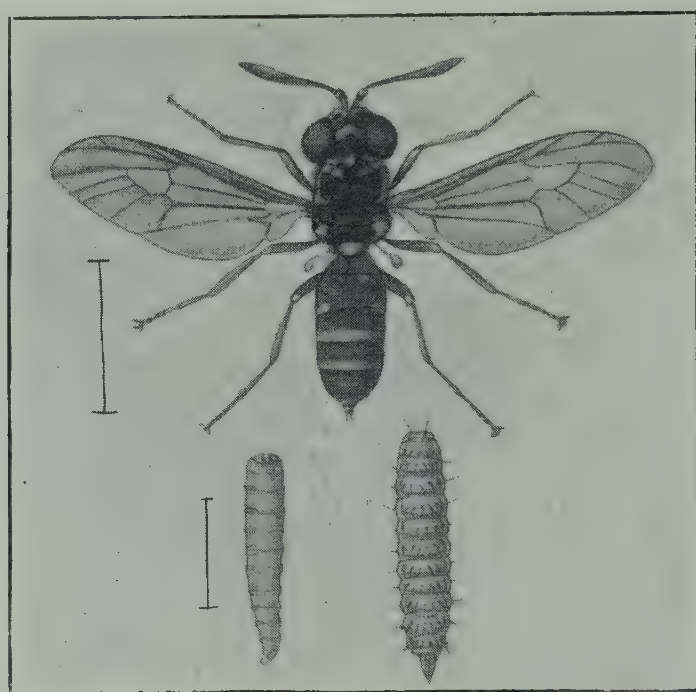

FIG. 79.
Dipterous Insect; Larva and Pupa below.

One pair of wings only. Suctorial mouth-parts. A metamorphosis, the larva being, as a rule, a legless maggot.

Hemiptera (*hemi*=half ; *ptera* = wings). The bugs.

The basal half of the upper wings often thickened. Sucking mouth-parts. No metamorphosis.

Distinguished from beetles most readily by the fact that the wings do not meet in a straight line, but overlap.

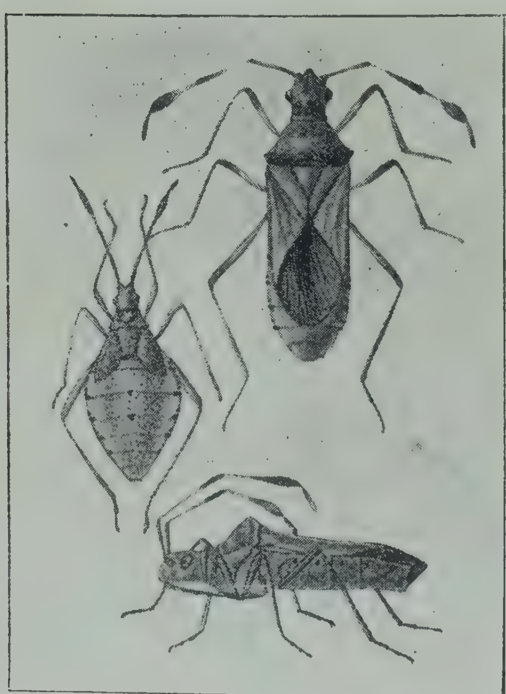

FIG. 80.
Hemipterous Insect.

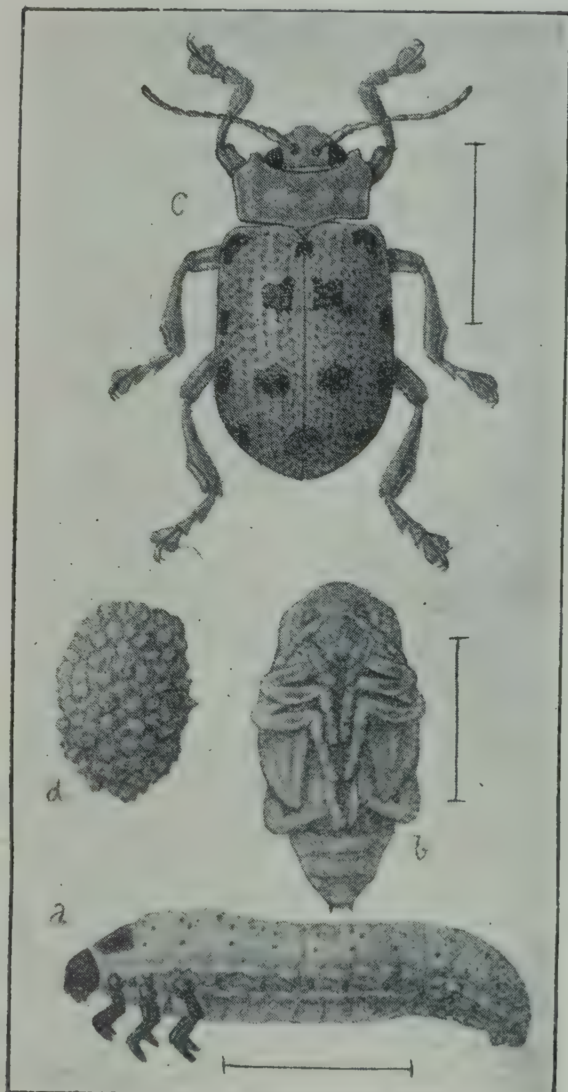

FIG. 81.
Fourteen Spotted Leaf Beetle.
a, *Larva* ; b, *Pupa* ; d, *Pupa case* : c, *Imago.* *All magnified but* d.

These seven orders are generally easily distinguished; look first at the wings, then at the mouth-parts; a two-winged insect is probably one of the *Diptera;* an insect with four clear, transparent wings belongs to *Neuroptera* if the wings are large; to *Hymenoptera* if they are small. If the wings are covered with scales, it is a butterfly or moth; if the upper wings are hard and meet in a straight line, it is a beetle, but if one lies over the other, it is one of the *Hemiptera.* In the latter case a glance at the mouth-parts will confirm it.

It is only the exceptions to these rules that make classification difficult, and as the apparent exceptions are numerous, one cannot expect to place every winged insect into its order by superficial examination.

When the insect is young, the case is more difficult; young *Orthoptera* and *Hemiptera* are of course easily distinguished by the mouth-parts. A caterpillar with not more than five pairs of sucker-feet belongs to *Lepidoptera;* if it has more, it is one of the few *Hymenoptera* whose larvæ resemble caterpillars. A larva without sucker-feet and not hairy is probably *Coleoptera* if it has a well-marked head,

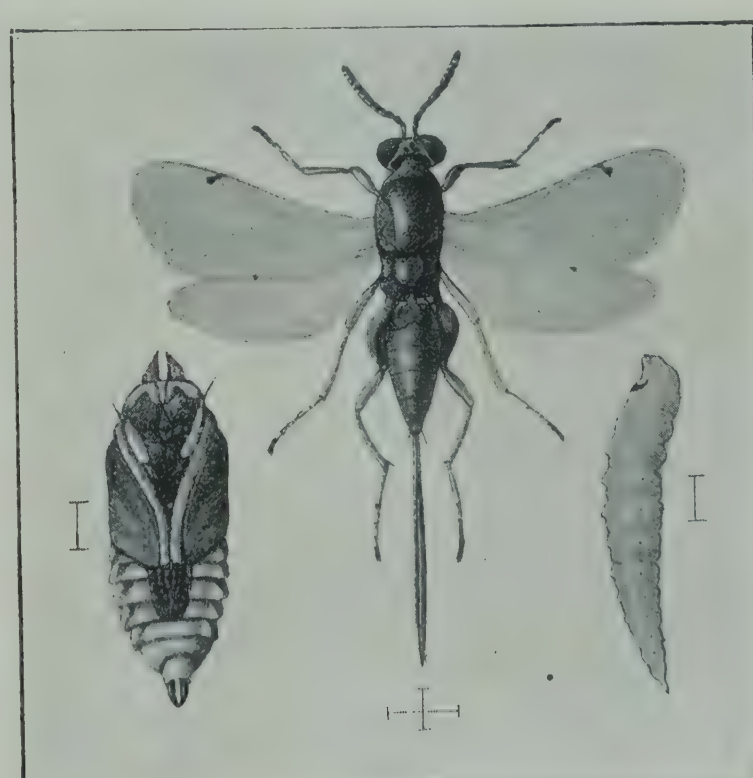

FIG. 82.
Larva, Pupa and Imago of a Hymenopterous Insect.

and *Diptera* if it is without any definite head. There are, however,

FIG. 83.
Diptera; Larva on left, Pupa in middle, Imago on right.

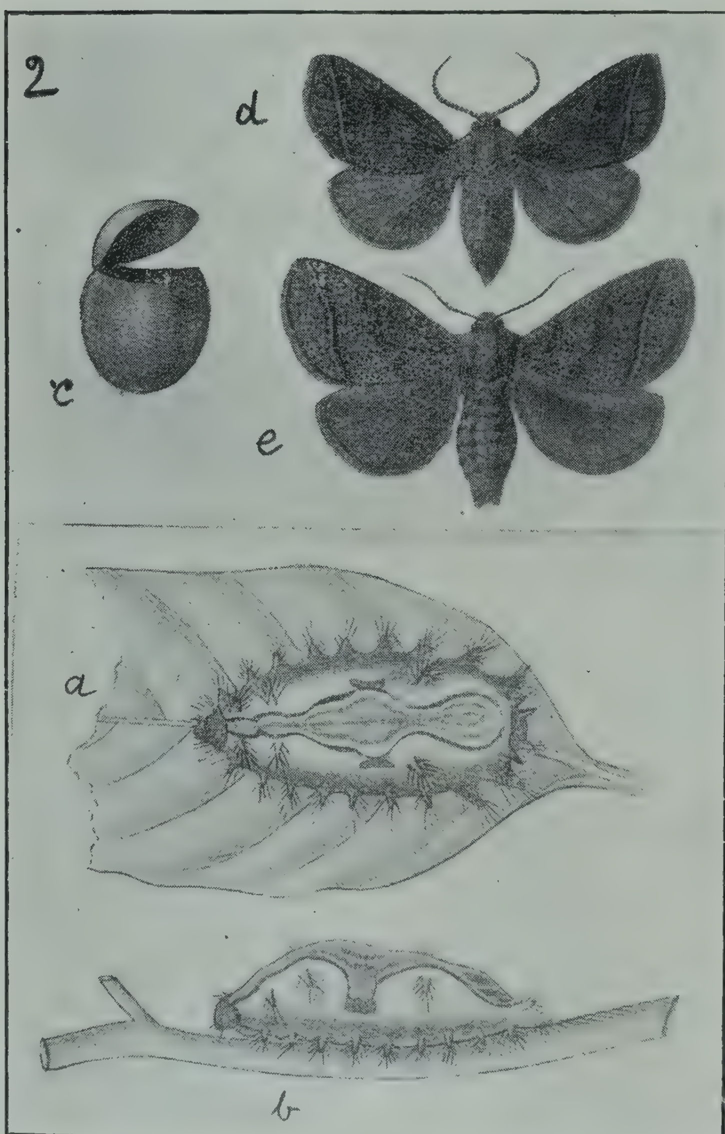

FIG. 84.
Slug Moth. a, b, *Caterpillar;* c, *Cocoon;* d, *Male;* e, *Female.*

no means of classifying larvæ accurately except by rearing them. The same is true of pupæ; but if the pupa is suspended from a plant, it is probably that of a butterfly; if it lies in a silky cocoon or in twisted-up leaves, it is probably that of a moth. Should it be in the ground without a cocoon, it may emerge as a beetle or a moth. If there be many in a nest together, they belong to *Hymenoptera*. The figures of different larvæ and pupæ will help in classifying them.

The following English terms are generally used for the larvæ of different groups:—

A *hopper* is the young (nymph) of a locust or grasshopper.

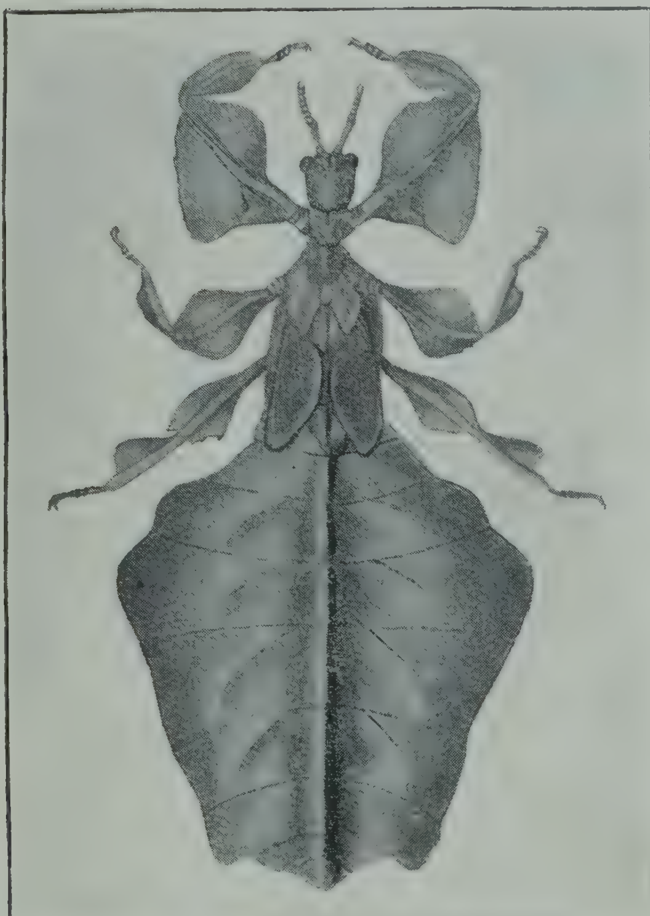

FIG. 85.
Young Leaf Insect. (*Compare Figure 49.*)

A *caterpillar* is the larva of a butterfly or moth.

A *grub* applies to the larva of *Coleoptera* or *Hymenoptera*.

A *maggot* is the larva of a fly (*Diptera*).

A *chrysalis* is the pupa of a butterfly or moth only.

Nomenclature.

Insects have been systematically studied during the last two centuries and only a small part of living insects have been examined. In India a very small part of the insect fauna is known, though some of the very common ones have been studied. In all, some two to three hundred thousand kinds of insects have been classified. Each of these has received a distinctive name.

In the first place, all insects that are almost exactly alike, that can breed together, and that may have been descended from the same pair of insects during recent generations are said to belong to the same *species;* species in fact are kinds of insects. A number of species which are similar in all but colouring or other

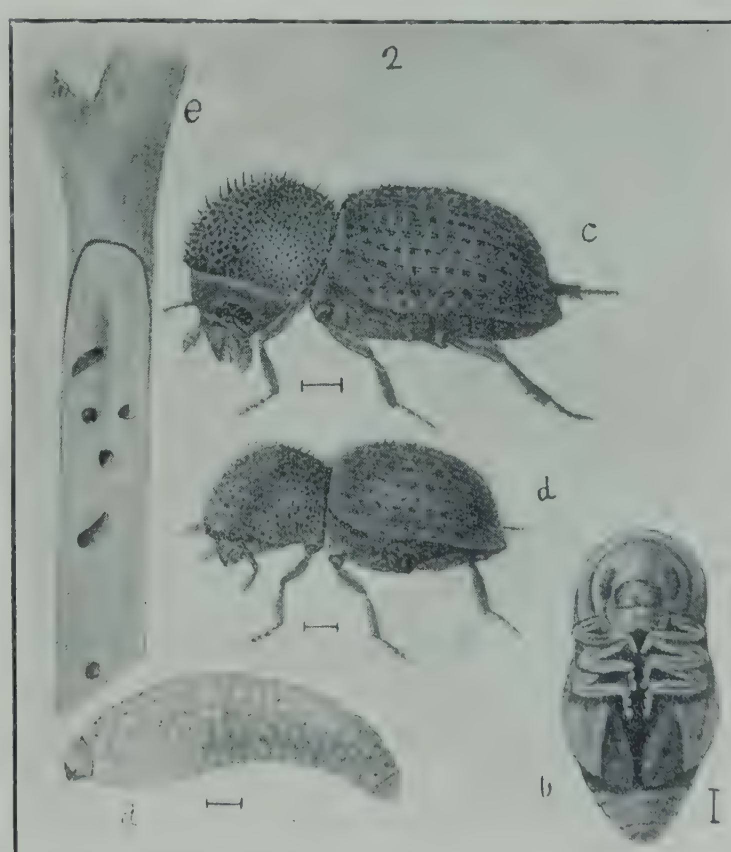

FIG. 86.
Wood-boring Beetle. a, *Grub;* b, *Pupa;* c, *Female;* d, *Male;* e, *Tunnels in wood.*

unimportant characters are said to form a *genus*. Each genus and each species receive names. Thus the Indian locusts belong to one genus, *Acridium*. Of these one species is *Acridium peregrinum*, another is *Acridium succinctum*, and so on. Each species thus has a double name, one for the species, another for the genus.

FIG. 87.
Mulberry tree Boring Beetle.

These names are generally composed of Greek or Latin words. In old days every one in Europe knew these languages, and so these names could be understood by scientists of all the European nations, whether they were French, German, English, etc. Originally these names had definite meanings, but the number of known species is now so great that almost any word is used put into a Latinised form.

At the end of every scientific name there is an abbreviation for the name of the person who first described and named that insect; thus the full title of the North-West locust is *Acridium peregrinum*, Oliv. '*Peregrinum*' is the name given to the species by Oliver, and as it resembles other insects of the genus *Acridium* it is put into that genus.

FIG. 88.
Grub of Mulberry Boring Beetle.

This system of naming insects is absolutely necessary for systematists and scientists; it is however very confusing, as entomologists are not agreed as to the original name given to each insect. Two

entomologists may find the same species in different places and both will describe and name it, using different names. Both names cannot be used, and it is now agreed that the name which was first published shall be used. This again causes great confusion, as people cannot agree which was the name first used.

It can be seen that the naming of insects is a very difficult matter; there are, for instance, some 2,500 species of grasshoppers and locusts described; of these perhaps 400 are known to live in India, but there are probably also in India some 400 more which have not yet been described; it is no easy matter to know, first, if any Indian grasshopper is the same as one of the 400 already described in India; second, whether it is the same as one of the 2,500 described from all parts of the world; or third, whether it is new; if it is new, that is, not yet described, it must be described as a new species and perhaps as a new genus. As locusts and grasshoppers make up only one of over 200 families of insects, it is clear that it is no easy matter to use the scientific names of insects correctly.

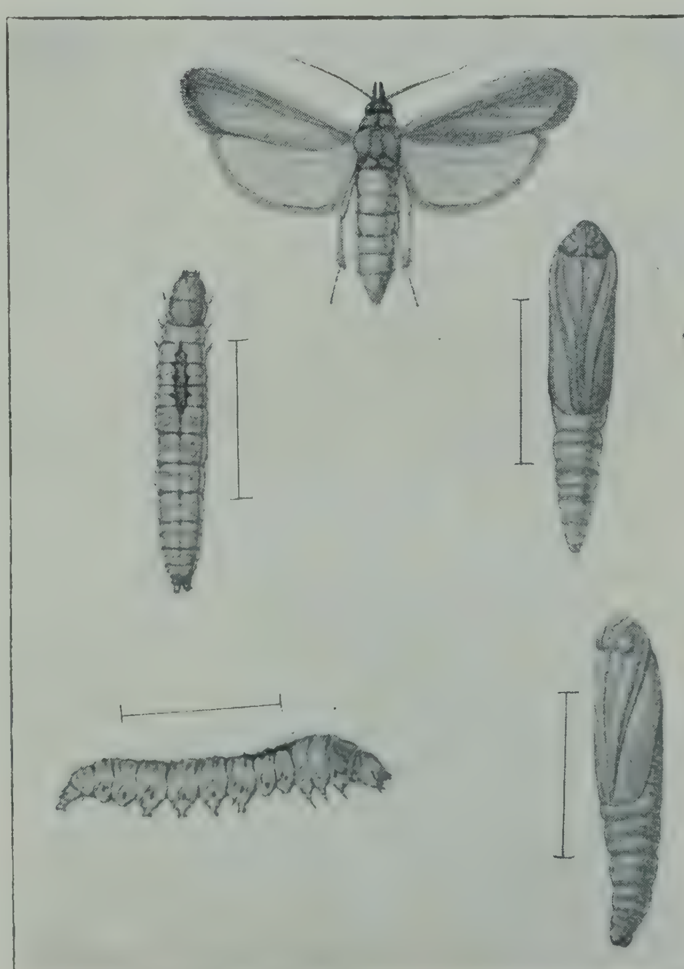

FIG. 89.
Caterpillar, Pupa and Moth.

In this book scientific names are not much used; it is as easy to learn about the Bombay locust as it is about *Acridium succinctum*, L. Persons who see an insect in the field and know that it is *Pentadactylorthopteroides vigintioctonigropunctulomaculata* N. are apt to forget whether it is a grasshopper or a beetle and whether it is injurious or not. No good is done by hurling scientific names at an insect in the field. It is far more important to be able to recognise a cockchafer, to know that its grub lives in the ground and eats roots, and to know that, if one is found, others are likely to be there and should be destroyed before they lay eggs. As far as possible, plain English names have been used for the

insects mentioned in this book. To avoid confusion and to assist reference, I have put as a footnote the register numbers of the official collection, the name of the family and what I believe to be the correct designation of the insects referred to in nearly all cases.

Part II.

PREVENTIVE AND REMEDIAL MEASURES.

CHAPTER V.

ORIGIN OF INSECT PESTS.

IT is well known that the natural increase of any insect would be very large if the restraining checks were removed. It is also true that a species rarely becomes so abundant as to cause serious damage to crops. We may here shortly discuss the causes which lead to the undue increase of an insect, so that it becomes a pest.

In this book we propose to record about one hundred species of herbivorous insects which have become injuriously abundant in recent years; this is a small fraction of the herbivorous insects common in the plains, which can and do feed upon crops. Why do not the larger part of these insects also become abundantly destructive? There is no answer to this question, nor has it ever been answered in any country; we can but dimly see the laws which govern the increase of animal life, and in this limited space we can but discuss some of the most obvious laws and phenomena which a close study of nature presents to us.

In the first place, let us examine the rate of increase of an insect. A single female of one of our commonest moths lays over 500 eggs. Of these actually 200 have been reared to moths again under artificial conditions; these produce 50,000 eggs, since roughly half are females. Of these again we rear 20,000 moths which produce 5,000,000 eggs. This is the rate of increase based on the actual ratio that live in captivity. We see that the increase of one moth in three generations is vast, equivalent approximately to ten large and devastating swarms of caterpillars. This is not a peculiar case, just one taken at random and well within the limits of any herbivorous insect investigated in India. We can see then that every moth feeding upon a crop plant should, if there were no checks, produce a vast progeny. Clearly also the checks are very efficient since this does not occur. The checks upon the increase of insects may be roughly said to be *climate, lack of food, enemies.*

Climatic checks are of great importance, and we cannot pretend yet thoroughly to understand them. Most insects become torpid with cold and hibernate (lie dormant) for some three months. Not only does this stop increase at this time but the hibernating insect is exposed to many dangers during this period—dangers it cannot guard against. Probably a very large percentage do not survive the winter. There is

then the period of dry heat, which is to many equally a period of rest during which their enemies are especially active. Finally there are four months of suitable weather, during which they can increase ; even this is probably not entirely favourable as it is likely that excessively heavy rain and wind storms do much to kill moths and flying insects.

The *lack of food* is another powerful cause ; as a rule, plants grow vigorously during the rains, many grow during the cold weather, after which a great proportion of the vegetation dies down. An insect feeding on a plant that grows only in the rains has but a few months in which to multiply; if it can also feed upon cold weather plants it has some months longer, provided it is not numbed by cold, and finally it has no food for some months of dry heat.

The third great check is due to *enemies ;* these include the parasites, the predatory insects, the birds, bats, etc. As soon as an insect becomes abundant, these attack it and reduce its numbers (see page 268). Fungoid and bacterial diseases are also operative in insects as they are in man and domestic animals.

In the jungle or forest, we find that, on the whole, these causes acting against the naturally large ratio of increase, tend to preserve an even level for all insects; what we may call the balance of life is maintained, and, neglecting small variations, in nature the numbers of each species are more or less constant over long periods. Where man has not interfered, insects do not become destructively abundant ; there are exceptions, of course, but then the balance adjusts itself very swiftly. We are, however, not dealing with the jungle where nature reigns, but with artificially maintained areas of cultivation. There man has upset the original conditions in very definite ways for which he pays the penalty.

Firstly, the balance of life is commonly upset by the new forms of life which are introduced by man himself or which come with him. The introduction of the Gipsy Moth to the United States let loose an insect whose increase was so enormous that as much as four lakhs were spent yearly in one State in checking it. The disastrous results that followed the introduction of the Indian mongoose to the West Indies, of the rabbit to Australia, of ferrets, stoats and weasels to New Zealand, of the sparrow to the United States, and of the Indian myna to the Hawaiian Islands are examples of the manner in which the balance of life is upset by the introduction of new forms.

Secondly, we may refer to the interference with the climate caused by the changes made upon the earth's surface by man ; such a change as the destruction of the forests is the most obvious case, leading to profound modifications in the climatic conditions of large areas.

Thirdly, the plant life may be entirely altered. This is by far the most obvious cause and deserves separate discussion.

Lastly, the interrelations of the fauna are deliberately upset by man in shooting insectivorous birds, in checking beneficial insects and in making the conditions unsuitable to useful insect-eating animals.

The last two are the really important causes that affect insects directly. In cultivated areas, we grow large numbers of the same plant side by side; any insect that can feed upon a cultivated crop finds abundant food, has not to search for it, and can readily lay its eggs in one place. Instead of searching through the jungle for the particular plant she requires, a female moth emerges in a field of that plant, finds a mate at once and can readily lay eggs; she is not exposed to enemies in her flights to find a mate or in her endeavours to find sufficient food-plants on which to lay her eggs. Not only does man grow larger areas, but he grows the plants at seasons of the year when food is otherwise scarce; the crops grown under irrigation in the hot dry weather help many insects over a critical time and so give them an additional opportunity of breeding and multiplying.

Further, plants grown under somewhat artificial conditions have not the same vigour to resist pests as plants growing wild in the jungle. Few crop plants are grown where they naturally thrive; in the jungle there is competition, there is a struggle for life and only strong healthy plants in good vigour can live; in cultivation plants are kept alive by stimulation, are grown in soil that does not suit them, are "domesticated" and have not the vigour that especially resists the plant parasites. How seldom we see a wild plant attacked by scale insects or plant lice? A wild plant has the vigour to resist, to make itself distasteful and to outgrow the disease.

In addition to helping the increase of insects by the artificial manner in which he grows his crops, man does so also by checking the birds and other predators which check insects. These include birds, lizards, bats, predatory and parasitic insects and the like. They are discussed in detail elsewhere, but we can see that our artificial conditions upset this part of the balance of life and so give opportunities for the abnormal increase of insects.

If we consider this question as a whole, we can dimly see that every now and then the checks which are usually operative may temporarily be suspended, so that we get a vast increase in the numbers of some common insect, *i.e.*, of an insect which, if abundant, probably destroys a crop. Then we have an outbreak of a "pest," a perfectly natural phenomenon due to causes which man himself brings about. In nature, and generally

in our cultivated areas, the increase of insects is automatically and naturally checked; at times it is not checked in our artificial surroundings, whereby we suffer.

These facts require to be borne in mind in considering our pests and the manner in which they appear. An outbreak of an insect pest is not due to supernatural phenomena, nor is it wholly due to an east wind, last year's flood, late rains or other causes. Cultivators commonly believe that the sudden appearance of a pest is more or less supernatural, and for that reason not capable of treatment; it is no more supernatural than when a bullock gets into a young crop and eats it, only we can trace the bullock and cannot always trace the insect pest. Above all we must remember that our insect pests are always with us, but not always abundant. Insect pests do not appear suddenly from nothing; they are the insects common throughout the plains, which under a certain combination of circumstances increase sufficiently to do damage. No conditions of manuring, irrigation or the like can *produce* them, but suitable conditions can enable them to increase beyond their natural limits and turn them into a pest.

As can readily be seen, the conditions which govern this very delicate balance of life are extremely complex, and we cannot always see what causes have led to a particular result. The preventive measures discussed in the next section, as well as one simple method of encouraging parasites (see p. 271), are based upon our knowledge of these causes. A little consideration further helps us in some cases to anticipate an outbreak of an injurious insect, on perfectly simple reasoning. An entomologist who sees hundreds of the moths figured on page 188 flying in March, as is commonly the case, will know that, if sufficient wild plants are not available, the crops will be attacked; he will also know that there must have been abundance of the caterpillars of this moth before the cold weather, and that probably they might then have been destroyed either in the crops or by more careful attention to clearing away weeds on waste strips and headlands.

Again, if we see a swarm of caterpillars in the fields or in uncultivated land, it is worth while ascertaining whether they are extensively attacked by parasites or not; if we see many flies (fig. 325) or ichneumons (fig. 323) among these caterpillars or laying eggs on them (a matter requiring but little observation), it is probably advisable not to destroy these caterpillars unless they are doing very great injury; if, however, we find no parasites or only small numbers, we must use every endeavour to destroy them or prevent them becoming pupæ, as the next outbreak will be a very large one. An agriculturist who understands something about these moths

will see ways in which he can turn his knowledge to good use either in preventing the occurrence of such pests or in checking them.

A subject that has unfortunately attracted general attention is the fascinating one of using one insect to destroy another. We know that there are parasites, predators and the like which destroy insect life; the inference is that we should be able to check all our pests by their means. Entomologists have devoted great attention to this point, with an almost complete record of failure. In one instance, under very peculiar conditions, success was attained, a ladybird beetle being introduced to destroy a virulent insect pest. The particular conditions in this case were that the pest was *newly introduced*, had no enemies in the locality to which it was introduced, and could be traced to the country whence it came. It was not difficult to obtain from that country the beetle that there preyed on it, and liberate it where it could find its accustomed prey, which was the only insect it recognised; it utterly destroyed the pest, partly because it had no other food and partly because it had no enemies in that place. Evidently this could be repeated with some chance of success, but only in the case of newly introduced pests. Our pests in India are probably of long standing; they have enemies here, but the fluctuations in the balance of life occasionally enable them to be destructive. No parasite, no enemy will entirely destroy an insect that is established throughout India, and there is no advantage to be gained by introducing fresh parasites. There is also no ground for believing that in the near future we shall be able to artificially employ fungoid and bacterial diseases in the destruction of insect pests; they appear to require special climatic conditions (*e.g.*, very moist heat), and this places the matter beyond our control.

What is of extreme practical importance is to encourage, not particular parasites that are already doing their utmost under conditions beyond our control, but birds which will destroy any insect that becomes too numerous. Birds are the fluctuating check on insect life, the safety valve as it were; they congregate where they find insects, regardless of their species or habits, and constantly consume the superfluous and superabundant insect life. We can encourage birds by planting trees, by letting them take a not too excessive toll from the fields; and every insectivorous kind means a large diminution in our pests. We cannot as yet equally encourage other beneficial organisms, but must rely on our own efforts to check the superabundant insect life that destroys our crops.

CHAPTER VI.

PREVENTIVE AND REMEDIAL MEASURES.

PREVENTION is better than cure, costs less to carry out and forestalls the loss of crop. Most measures of this kind depend upon a kind of commonsense that is practically non-existent in India and rare anywhere. It is difficult to prove the value of preventive measures, which depend solely upon a thorough knowledge of the conditions under which insects live or upon reiterated experience. If our pests come regularly and at definite times, the value of such measures can be clearly demonstrated; but since insects are not so accommodating and come at haphazard, it is difficult to bring them within range of actual experiment. There are several simple precautions which are sufficiently obvious to any one who practises agriculture intelligently; they are also general in their application and should form part of every agriculturist's stock of maxims. Clean culture is important; many insects breed on common weeds, become abundant and are driven by lack of food to attack crops. That is a common way in which many insects become pests. An herbivorous insect that increases beyond natural limits will attack a crop on which it can feed, and it is folly to encourage pests by growing their wild food-plants within reach of cultivation. Weeds are always a source of danger and do no good. This applies equally to the strips of grass that border on fields, to waste lands, jungle, etc. Good grass is safe and brings no pests; mixed weeds and low vegetation should be replaced by grass or kept down. The ideal cultivator allows no weeds or plants to grow other than crops and grass.

Another precaution consists in removing crop plants when the crop is harvested. Old cotton plants afford food to cotton pests, thus helping them through critical seasons when food is scarce. Juari stubble harbours the moth-borer and enables it to hibernate. A crop plant that has yielded should be removed and not allowed to breed pests after it is useless. It is at all times necessary to weed out dead and dying plants from a crop and burn them. The brinjal grower pulls out the plants attacked by stem-borer and leaves them in the field. If he burnt them, he would destroy his pest and check its increase; as it is the caterpillar completes its metamorphosis, comes out as a moth, lays its hundred eggs and the loss of plants steadily increases. The same thing applies to all refuse plants, dead wood, rotting fruit, etc. Even weeds should be removed when they are pulled up and not allowed to rot in the field. No vegetable matter should ever be allowed to decay in a field or anywhere

but in a proper compost heap. The useless cotton bolls not worth picking breed cotton pests and do much harm; they should be removed periodically and carefully burnt with all their inhabitants. He who leaves fallen mangoes to rot where they fall should not be surprised if his sound mangoes are attacked by pests bred in the fallen ones.

Rotation of crops is a practice of some value and is more valuable the larger the area rotated. Keeping two acres side by side in sorghum and cotton alternately does not help matters so far as insects are concerned; but the rotation of large blocks of land in alternate crops does much to check pests. In rare cases it is possible to check a pest by not growing its food-plant for a year or longer, substituting other crops.

The practice of growing mixed crops has a profound influence upon insect life and is generally most beneficial. Growing crops in separate blocks which might be mixed and grown in alternate rows is a direct incentive to insect attack, and the mixed cultivation of the Indian cultivator might well be followed in other countries where pests are rife. Mixed crops approximate to natural conditions and discourage the increase of insect pests. Cotton grown with tur, urd or maize suffers less from insect pests which do not so easily find the cotton; the moth has to search for her food-plants, and in so doing runs risks of enemies; the caterpillars cannot simply crawl from plant to plant, but must move over the ground with the risk of being snapped up by ground beetles, frogs or birds. The mixed crop is a great safeguard, though the cultivator does not know the reason but benefits by the accumulated experience of distant ages. Opposed to the mixed crop is the small plot of any single crop. A small area of a single crop in a large area of other crops is an inducement to insects to cluster in that small plot, and destroy it. Insects which are harmless when scattered over one thousand acres are extremely destructive in a small plot, and probably devour it all. Nothing is more fatal than to grow a small area of a plant; it is not the small plot but the relative area which matters; if a crop is grown in its due proportion, say one thousand acres in five thousand, it may be broken up into small plots, but the insects are scattered over the district; but if there is only one plot of say ten acres in that five thousand acres, then that plot is liable to suffer. Many promising experimental cultivations of crops suffer because insects gather in that one little plot. If the experiment had been on a larger scale or if the pests had been checked, the experiment would have had a better chance of giving true results. If one grows plants under such conditions, one must expect abnormal results and take measures accordingly.

Much encouragement is given to pests by the promiscuous growth of plants that harbour pests at seasons when the crops are not available.

Bhindi is a plant that should be rigidly excluded from cotton areas, as should *hibiscus*, the roselle hemp (*ambadi*, *sherria*, etc.), the holly-hock and a few other malvaceous plants. If grown they should be grown only where cotton is also growing so as to draw off the pests from it. There is probably a large field for the prevention of pests in this way, but we have not yet obtained the requisite knowledge of Indian insects to be able to make use of it. Equally we do not yet know how to use trap crops to the best advantage. Trap crops are crops grown to lead the pests off from the valuable crop plants. The cultivator who sows mixed seeds in an irrigated plot of land and pulls out half of the plants with caterpillars on has unconsciously used a trap crop and saved his really valuable plants. If he went one step further and destroyed those caterpillars and plants he would do still more good and use his trap crop intelligently. There are two ways in which trap crops can be used; we can sow an early small crop for the insects to eat, sowing the bulk of the field later and destroying the early crop with the insects on or leaving it until the main crop is well established; we can sow two crops together, one a valueless crop to act as a bait for insects and which grows only so long as it serves its purposes, being destroyed as soon as it is full of pests or as soon as it interferes with the growth of the main crop. Neither method has been adequately tried in India, though the latter is unconsciously done by cultivators, and in rare cases deliberately; the method deserves to be far more widely tried on an experimental scale.

The most valuable of our preventive measures after mixed crops is the practice of killing whatever caterpillars are found in crops, when they are few. If cultivators realise that caterpillars are not harmless and that anything that eats his crop may become a serious pest, and if he would but kill these stray insects from the first, they would not multiply to the extent that they now do. At present the first brood of insects is never killed, the second is larger and does more harm; the third eats the whole crop or perhaps emerging next season after hibernation wipes out the young crops. If the first brood were checked, there would be no second or third brood and no loss to the crop. Such a procedure is far more possible in India than in other countries; the process of picking off caterpillars is one that is not essentially different from the process of laborious hand-weeding and can often be done at the same time. It is as natural and feasible as weeding, only it has never become part of established usage. Caterpillars are always safe things to kill, though other insects are not, and it is from caterpillars that most of the harm to agriculture comes.

A common practice which helps crop pests is that of letting stray crop plants grow either at the wrong season or in the wrong field. Stray

plants of maize, of bhindi, of juari, of beans, of any crop plants should never be grown in the fields at any time. They come up from stray seed and are allowed to grow freely, perhaps in border strips ; they harbour pests and help them over critical periods when food is scarce ; all such plants should be pulled up unless grown for a distinct purpose.

A precaution that might be used far more freely is that of trenching, either to isolate an infested plot or to protect an uninfested one from a neighbouring infested one. When caterpillars are abundant, they eat the plant they are on and move away to others ; rarely they move in a body, usually singly ; the owner of an infested plot is doubtless glad to see them go, but his neighbours should certainly make trenches, which need not be more than a few inches deep with sloping sides. Such trenches do much to isolate pests which cannot fly, especially caterpillar plagues ; these caterpillars often become restless and move about at a special period of the day, falling very soon into the trenches ; large numbers can then be killed in a very simple manner.

Another simple precaution on small holdings is the common hen, an indefatigable insect hunter ; turkeys and guinea-fowls are equally good but rare. The hen should be a regular part of a ryot's small belongings, and there is a certain justice in obtaining fat hens from the insects which eat crops ; it is necessary to give the hen a basis of other food and not compel her to a purely insect diet.

Whilst there are many methods of destroying insect life on a small or large scale, for every pest there is, as a rule, one single remedial method which proves successful. There is no one specific capable of universal application, no "cure-all," no patent medicine warranted to kill every thing from fleas to locusts ; if there is, it has not yet come within the range of practical science and is made only to sell and not for use.

In devising remedies, the essential things are a knowledge of the habits of the insect and a full understanding of the local conditions. The habits of the insect vary little from place to place, and their variation can be predicted ; but local circumstances vary from village to village, and what is effective in the west may not suit the east. Thus it is that no remedies can be given for such a pest as the Rice Stem Fly ; its destruction is purely a matter of local knowledge and of so altering the local agricultural practices as to baffle the insect ; no amount of scientific training, no remedies from the most advanced scientific nation can help us in a case like this, and nothing can replace the local knowledge that, combined with a knowledge of the habits of the pest, at once points to the one weak spot in the life of the insect and adjusts the agricultural practices accordingly. That is the essence of remedial measures.

The remedies described below are those so far tested against crop pests in India; they have been laboriously worked out after many failures and in the face of many difficulties; they are in the nature of suggestions, not of recommendations; such suggestions as are of value when one is face to face with a pest and seeking for some method that will fit in with the agricultural conditions and with the ways of the insect. It is not to be supposed that any one can read these pages and find a remedy for every and any pest. At best they are suggestions, which are the pick of the methods used abroad and which should be familiar to those who experiment with crops; when the pest comes, some method may be modified with practice, which will perhaps meet the case and give good results. No remedy is of the slightest use unless done thoroughly and with the full determination to destroy every single insect; if one could but educate the ryot up to that feeling, there would not be a pest left in densely populated India.

The simplest method is to pick the insects off the plants one by one and kill them. This is tedious, but satisfactory and effective. As stated above, the common hen is perhaps the best agent for the purpose, but it is a remedy far more suited to the ways of India where holdings are small, time is plentiful and patience unending than to other countries. Having secured the insects, there is no difficulty in killing them; a pot of hot water, a little kerosene floating on a pan of water, two flat stones or a fire are all equally effective. The practice of carefully picking off caterpillars and liberating them at a distance of say one hundred yards from the infested plot is not only ineffective and futile but needlessly cruel.

FIG. 90.
The most useful bag, with cross bamboos joined to the upright side bamboos, allowing the mouth to be instantly closed.

An improvement on hand-picking is a bag, a basket or a net. The bag is a most valuable instrument, which can be made to suit all circumstances; with a width of 12 feet and an opening 3 feet high, it sweeps

large stretches of grass land; made smaller, say ten feet by two feet, it can be run over a rice crop, over wheat, lucerne, mustard, etc.; smaller still, it is attached to the frame of bamboos and a single man draws it between the rows of crops, along grass strips, in any narrow places. The simplest pattern has only two upright bamboos to hold open the sides; a better one has four bamboos, the two cross ones with projecting handles, and this pattern closes up automatically at the end of each sweep.

FIG. 91.
Bag with two upright bamboos.

The depth of the bag depends upon its use; on the ground it may be five to seven feet deep; but should be shorter for use on crops where it has to sweep over the plants and not hang too much. At the end of each sweep the bag is emptied into a hole in the ground; where the insects are very active, it is twisted up to crush them and then opened. (See page 288, appendix A.)

FIG. 92.
Small bag with two cross bamboos.

In some cases it is desirable to smear the inside of the bag with kerosene oil, heavy oil or tar to catch the insects as they fly in; a bag which is slightly moistened with kerosene is more effective because the kerosene at once kills many insects.

The basket is an adjunct to hand-picking when it is possible to shake insects off the plants into the baskets and then into a tin of kerosene and water, as recommended for the Red Cotton Bug (page 104). It is useful for weevils and plant-feeding beetles.

The net takes the place of the bag in some cases, as when catching the Banded Blister Beetle. What is required is a bag of cloth cut as figured (page 289) and sewn up, fastened to a slip of bamboo that is lashed to a short handle. The component parts are very simple, the net easily made and it does good service in gardens and small holdings where such insects abound. The practice of trenching has been mentioned above; it is useful when one is catching caterpillars with bags as many escape the bag, wander about the soil and fall into the trench, where they can be killed.

Baits of cut vegetation are useful traps. Many injurious insects hide during part of the day and will do so in bunches of green vegetation, if these are laid about the field. The bunches must be examined periodically and the assembled insects shaken off into hot water or kerosene and water.

Lights are useful traps for a few insects, especially for such as fly at night. Their use is very limited and fires are often as useful. The light trap consists of an ordinary kerosene lamp hung over a broad tray containing jaggery and water or water with a film of kerosene. Two bent pieces of tin serve as reflectors. Cockchafers, some moths, ants and a few other insects are generally captured and the trap has a value in certain specific cases.

Smoke is a deterrent to some insects, notably such as attack rice and other dense crops in which smoke hangs well. The smoke of a few fires will not kill anything, but may drive out such an insect as the Rice Bug at a critical moment when the grain is forming. The same applies to cockchafers, which attack grain crops just as they are ripening and which have to be kept off until they die naturally or until the grain is hard enough to resist them.

Cultivation in the form of hoeing, surface ploughing, etc., is valuable chiefly in exposing insects to birds or weather and is less a remedial measure than a preventive of attack; many insects that eat crops harbour in the soil or descend there to pupate; when this is the case cultivation turns out many to become the food of mynas.

Other simple remedies are discussed above under "Preventives." A great deal can often be done to check a pest by sacrificing a portion of the crops that is first infested or by sacrificing a young crop with the insects on, in the hope that a second crop will grow up free of the insects. A caterpillar-infested crop can often be wisely fed off to cattle or cut down, when a new crop is likely to come up.

CHAPTER VII.

INSECTICIDES AND SPRAYING.

THE essence of remedial measures is to attack the insect directly, to make life unbearable to him, to do something to kill him or to drive him away. Such methods are but little known in India; the methods of killing insects on a large scale, of poisoning acres of crops, of putting machinery on to deal wholesale destruction, do not occur in Indian agriculture. At most, simple methods aimed at frightening the insects are adopted without any co-operation. With the cultivator's knowledge of the medicinal value of plants, it is somewhat strange that plants are not used as insecticides to a greater extent. The juice of some plants is poisonous to insects, as is the infusion of the dried leaves and roots or the smoke made by slowly burning the dried plant. But such plants are little used; the juice of *Euphorbia neriifolia* is used to smear toddy-palms in Gujarat; the leaves of *nim* are believed to keep off insects; the infusion of *Adhatoda vasica* or of *Calotropis* is used in irrigation water, as are such substances as castor cake and *khurasani*. Dekamali gum, asafœtida and similar drugs enter into the composition of such mixtures as "Gondal Fluid." These are examples of the use of plants, but they rest on no basis but that of tradition and are not always effective.

It is singular that the value of tobacco infusion does not appear to be more widely known; this is one of the few plants used as an insecticide in Europe, with hellebore (*Veratrum album*), pyrethrum (*Pyrethrum cinerariæfolium*), quassia (*Picræna excelsa*). From the use of these plants, European methods of checking insects have developed more in the direction of mineral poisons, a branch of entomology never practised in India. At the present time far more reliance is placed on mineral poisons than on vegetable poisons, and even the Kentish hop-grower is abandoning quassia for soft soap. This is true also of America, where the use of purely mechanical methods of checking insects is also being developed to a high pitch. It has yet to be shown how far Western methods are applicable in the East. To the Western mind it is far simpler to poison the plant by spraying on lead arseniate than it is laboriously to pick off the individual caterpillars. The Eastern mind has not yet fully grasped the idea that insects could be or should be killed by hand-picking, far less by such a method as poisoning the plant with

arsenic. If there is any value in the use of insecticides in India, their general adoption will be a matter of slow growth that must first be worked out on the experiment farms.

Insecticides are insect poisons and act in two ways. There are those poisons which are placed upon the food of the insect and which act upon its stomach, just as medicines and poison do upon human beings. These are called *stomach poisons* and are meant only for internal application.

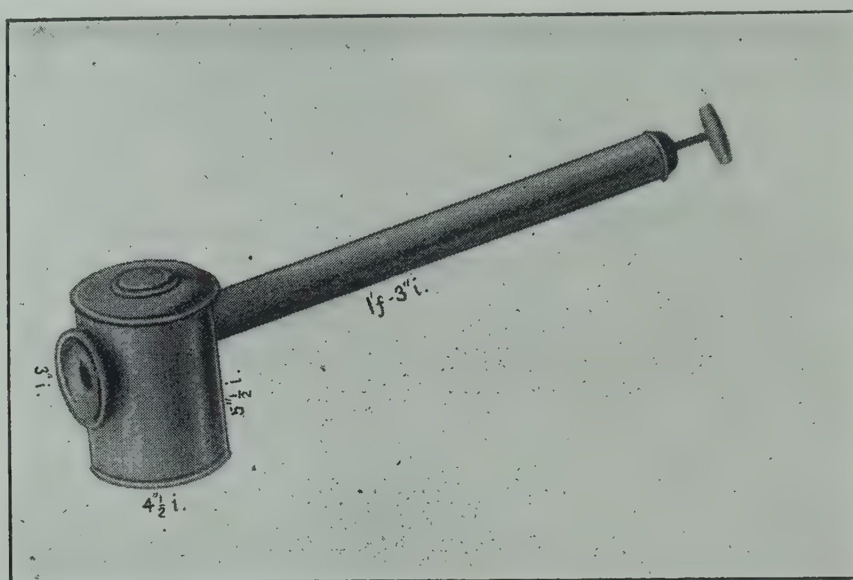

FIG. 93.
Hand Sprayer.

If caterpillars are destroying the leaves of a valuable plant and we can put poison on these leaves, the caterpillar eats the poison with the leaves and dies. It is only necessary to put such poison on the leaves of crops, and they are safe from all caterpillars, grasshoppers and other insects which eat the leaves. There are also many insects which do not eat the leaf, but which suck out the juice; these feed upon the sap of the plant, not on the leaf, and any poison on the leaf never reaches their stomachs. For these we cannot use a stomach poison as we cannot poison the sap of the plant. In such cases we must use poisons which kill when the insects are wetted with them. These poisons are known as *contact poisons,* since they work only when in contact with the skin of the insect. If a colony of plant lice is sucking the juice of a cotton-plant, we cannot poison the juice, so we throw contact poison on the insects; all are killed, and if the contact poison is properly made the plant is uninjured. Both kinds of poisons have their uses; we can poison any insect, even a locust, with contact poison if we use it strong enough, but it is better always to use a stomach poison for a biting insect, such as a locust; whereas for sucking insects we can never use a stomach poison and must always use a

contact poison. Stomach poisons are in general far cheaper; contact poisons for large insects require to be very strong and may injure the plants; stomach poisons should always be used if possible, but if they cannot and no other method is available, we must use a contact poison.

In using insecticides we must have a method of putting them quickly over a large surface of plant or insect. The value of insecticides lies principally in the rapidity with which they can be applied to a large area of crop. Insecticides can be applied in liquid form with water or as powder mixed with lime, dust, flour, etc. An insecticide applied as powder requires only to be dusted on from a bag and this is the simplest method of application. A liquid insecticide must be applied as a fine spray or mist that wets evenly and distributes the liquid properly over the whole plant. For this work the spraying machine must be used.

Spraying machines are of many kinds, all designed to fulfil the one purpose of distributing fluid in a finely divided form over a large area of plant. The simplest pattern is the tin hand sprayer (figs. 93-94). It consists of a pump, which forces air out of a fine nozzle; the compressed air passes over the opening of a vertical tube, and sucks up a small quantity

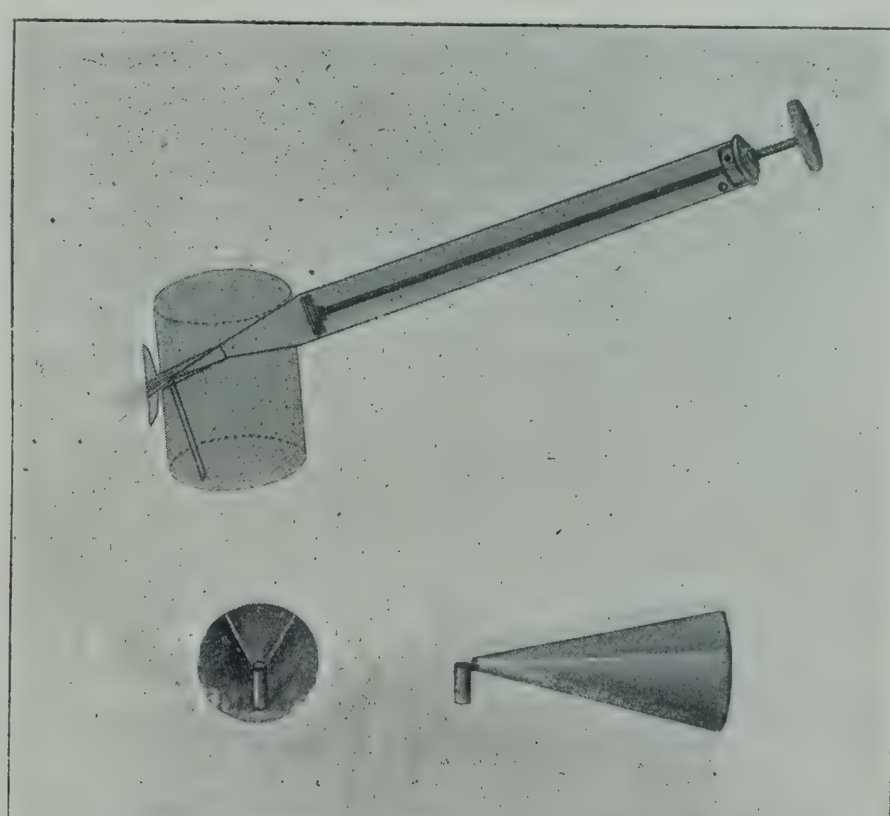

FIG. 94.
Hand Sprayer; details of construction.

of the insecticide in the reservoir, throwing it out in an extremely fine condition in the jet of air. The whole machine is made of tin and

wood, costing under two rupees to prepare. It covers very little ground, however, and is suitable only for gardens and small holdings. It is especially useful for applying contact poisons to small colonies of plant lice, mealy bugs and other sucking insects. With it one can rapidly and effectively kill such insects when they are few. It is not adapted to larger areas, but as a check on incipient diseases it is invaluable and admirably suited to the ryot. If this were in general use, the plant lice that ravage cotton, wheat, mustard and other staple crops could be nipped at the start and never get a real hold on the crop.

For more extensive spraying, a larger machine must be employed, and the Success Knapsack Machine[1] is a useful pattern obtainable in India at a cost of Rs. 46. This machine holds four gallons of insecticide and can be worked on the ground for spraying fruit trees or on the back for spraying crops. The insecticide is pumped through the rubber hose out at the nozzle which breaks it up into a fine mist. Either of two nozzles can be used, and of the two the Bordeaux has the most general application and value. The machine is built of copper and brass, which are not destroyed by insecticides. It requires to be kept clean and will last for years with the occasional renewal of the rubber tube. With this machine from one to two acres of crop can be sprayed in one day, using two men at the machine and others to bring water, mix insecticides, etc. This refers to cases where continuous spraying is required as when a whole crop is to be sprayed with lead arseniate. Where individual plants here and there are to be sprayed, as when *aphis* is attacking cotton, a far larger area can be covered daily. Larger machines are used to apply insecticides to fruit trees, to special crops and, in Europe and America, to field crops. It is unnecessary to discuss these at present as they are not likely to be used for field crops in India.

Fig. 95.
Success Knapsack Sprayer.

[1] English copies of descriptive leaflet are available.

They can be obtained on wheels to work by hand, on carts to work by gasolene engines, or portable outfits on the plan of a fire-engine are prepared which work by steam and cover a large area daily.

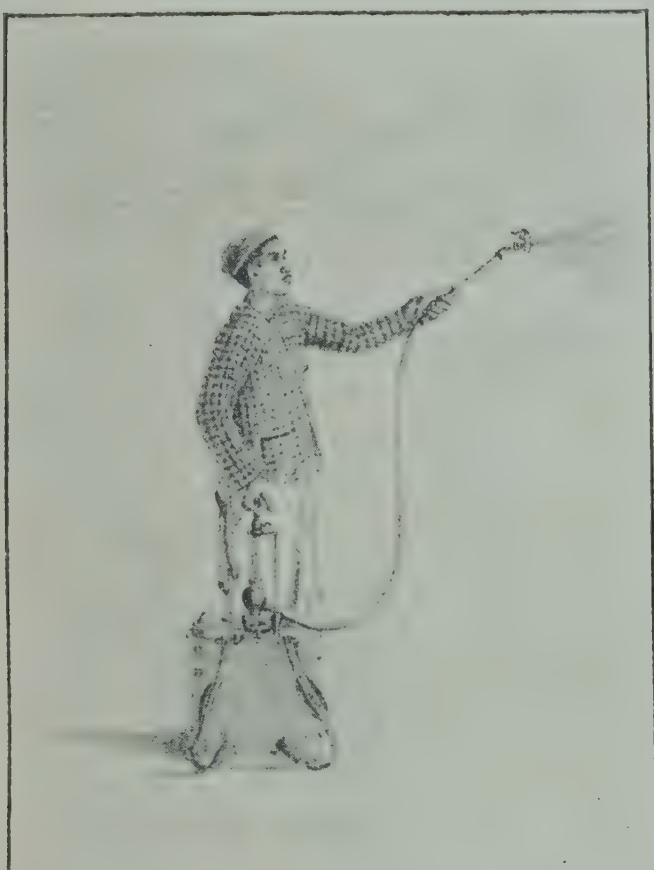

FIG. 96.
Success Sprayer used on the ground for spraying trees.

The choice of insecticides for each case is a matter requiring care. The principal insecticides are s hortly described with their uses. The formulæ for preparing these mixtures are given in Appendix A, page 283.

Lead Arseniate.

This is practically the only useful stomach poison available in India, and no other is required. Lead arseniate is a form of arsenic which combines the best qualities of the older stomach poisons, London Purple, Paris Green, etc., with qualities peculiar to itself. It is a white substance, procurable in powder or paste, which is insoluble in water, harmless to plants, and easy of application in the form of liquid or powder. It has a considerable power of resisting rain and so remaining on the plant in wet weather, and its white colour shows up on the plants to which it is applied. It is poisonous to cattle and human beings if taken in any but a very small dose, but it can be applied at such strength as to render plants poisonous to insects though not to cattle. Sprayed on to plants at the rate of one pound in 60 to 100 gallons of water, it is effective as a poison to insects, and its efficacy is increased by adding jaggery, gur or molasses and lime. The usual mixture is one pound of arseniate, three pounds of lime and six pounds or less of any form of low grade sugar or molasses with the necessary water. It can be used at double this strength with full safety to plants. Applied as a powder, it is best mixed with twenty parts of wood ashes, road dust, cheap flour, powdered lime, or any other cheap neutral powder: it can then be placed in rough cloth bags and shaken over the plants.

It is applicable against all forms of biting insects; it kills caterpillars, locusts, leaf-eating beetles, and other insects which eat leaves. For an average, crop of cotton, young juari or maize, pulse, castor, wheat,

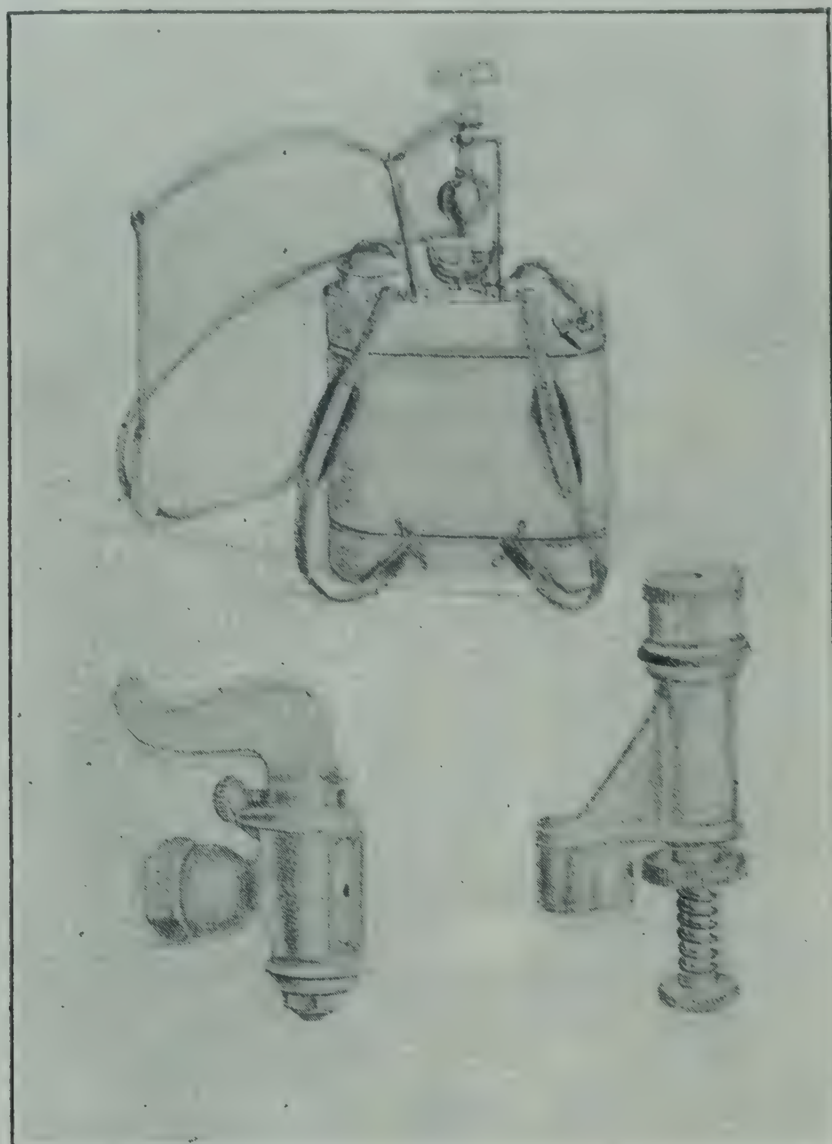

Fig. 97.

Success Knapsack Machine: below—left, Bordeaux nozzle; right, Vermorel nozzle.

etc., from 80 to 100 gallons of mixture are required per acre using from 1 to 1½ lbs. of lead arseniate. This explains its small poisonous effect on cattle, since there is so little arseniate actually on each plant. An insect eats so large a proportion of food compared to its size, that it absorbs relatively much more of the poison and is killed. Experiments made in the Punjab with bullocks fed on fodder dipped in the mixture showed that no harm resulted, and that freshly-sprayed fodder could safely be fed to cattle. As a matter of practice, the lead arseniate would not remain on a plant after the lapse of a week or longer, and the crop would have scarcely any poison on it after cutting and harvesting. In small gardens, in plots of vegetable crops, it is simply applied

by means of the hand sprayers, and it should be kept for this purpose. On farms, it is useful against many pests which attack valuable crops and render useless the results of other experiments whose value is shown by comparative yields. Every experimental farm should keep and use lead arseniate, applying it with a good spraying machine and in powder form. It is obtainable from chemists at Re. 1 per lb. in powder or paste form. The paste contains 33 per cent. of water, and $1\frac{1}{2}$ lbs. of paste are sold as one pound of lead arseniate and should be used as one pound in mixing with water before spraying.

Kerosene Emulsion.

The most useful and simple contact poison is kerosene, the ordinary refined kerosene used for burning in lamps. It kills all insects when applied to their bodies, though its action is not fully understood. It acts partly by mechanically closing the respiratory openings on the side of the body, thereby asphyxiating the insects; possibly it has a directly poisonous effect on the tissues of the insects when the vapour is absorbed through the system of air tubes which penetrate the body. Applied by itself, kerosene kills the parts of the plants on which it is placed so that the application of undiluted kerosene is as a rule fatal to plants. It has therefore to be applied in a diluted form, and, as it does not mix with water, it is made into an emulsion with soap and water. An emulsion of kerosene consists of water with kerosene in very minute drops; and on applying such an emulsion, the water evaporates leaving a minute quantity of kerosene on the plant, which is fatal to the insects, but does not injure the plant. The value of kerosene emulsion lies simply in the fact that it can be applied at such strength as to be fatal to many insects and yet not injurious to the tender tissues of the leaf.

Kerosene emulsion is prepared by boiling a solution of soap and water, adding kerosene and agitating or beating up the mixture so as to break up the oil into very minute drops, which gives the liquid a creamy white appearance. Such an emulsion can be made very strong and afterwards diluted with cold water to the proper strength for applying to plants. In cold countries, kerosene can be applied to leafless dormant trees in much greater strength than in hot climates. In India a strength of 10 per cent. of kerosene can rarely be exceeded. Kerosene has a peculiar way of "wetting" or penetrating insects which are protected by a covering of mealy white wax. It is therefore particularly effective against mealy bugs. It kills aphis (Green-fly), the softer scale insects, green bugs, small sucking insects and also some of the

more delicate caterpillars. Its use is strictly limited to these insects and it cannot be used, for instance, to kill large caterpillars which are best dealt with by means of a stomach poison.

Kerosene emulsion applied in the ordinary tin hand sprayer, is an excellent remedy for the *aphidæ* which attack cotton, tuer, beans, pulses and other field crops. In botanic gardens it is useful against all aphis and the majority of the scale insects. In vegetable gardens it can be safely applied against similar pests, and is often usefully applied over the whole of a garden to drive out unwelcome intruders such as crickets, grasshoppers, leaf-eating beetles, plant lice, jumping lice and other insects which are apt to gather in a well watered garden.

Crude Oil Emulsion.

The heavier petroleum oils have a more permanent and thorough insecticidal effect, especially where the climate is hot and the lighter oils soon evaporate. The ordinary emulsions cannot be made with the crude oil, the best emulsions containing crude oil being made by a special process. Such an emulsion, containing 80 per cent. of crude oil, with 20 per cent. of whale oil soap, is prepared and sold, under the name of "Crude Oil Emulsion." It was made at the Entomologist's suggestion, and analysis shows it to be pure, containing the ingredients given above.

To use the emulsion, it needs to be mixed with cold water in the proportion of $\frac{1}{3}$ pint to a kerosene tin of water (4 gallons). This amount measured and placed in a bucket or tin, is readily mixed with water by pumping water on it from a spraying machine or rubbing up the emulsion by hand. It makes a white milky fluid, remaining fit for use for several days, which needs no further preparation before application. This is the usual strength : it may be made twice as strong and can then still be used safely on all but very delicate plants.

Like kerosene emulsion, this is simply a useful contact poison. It is harmless to all animals if eaten and has a deadly effect on insects only when they are well wetted with it. It should be applied in the form of fine mist by means of a good spraying machine. For all soft insects such as aphis (Green-fly), mealy bug, thrips, green bug, leafhoppers, small caterpillars, etc., it is effective. One application kills the greater number and a second application completes the operation. In gardens, on fruit trees, on ornamental plants, on vegetables, it is a useful application for these diseases and has a further use in driving off many other insects, which though not killed by it, find it objectionable. It has a certain value also in houses, which are infested with obnoxious insects, etc. It

acts simply as a high class insecticidal soap, with a less objectionable smell than carbolic preparations. In this way it is deadly to fleas for instance.

It has a further value on domestic animals : kerosene is an excellent application for the skin and there is no better way of applying it than in the form of soapy emulsion. For ticks, fleas, and other insects infesting cattle, horses, dogs, elephants, sheep, etc., this emulsion should be used, at the same time destroying the insects and improving the skin.

It is obtainable in five-gallon drums from chemists at Rs. 8-14-0 per drum.

Rosin Washes.

Rosin has for many years formed the principal ingredient of many excellent washes for sucking insects. When boiled in water with a suitable chemical, rosin dissolves, forming a clear brown wash which can be safely applied to plants at a strength sufficient to kill many insects. It is used in this way against many of the most resistant scale insects. A rosin wash of this kind on drying forms a varnish, which asphyxiates some insects by closing the stigmata on the sides of the body through which they obtain air. It needs to be applied as a fine mist, by means of a good spraying machine, and then has a considerable wetting power, covering the insects with a film of liquid which on drying kills them.

There are a variety of formulæ for preparing this wash. Two may be taken as being the simplest and best, both having been tested in India and found fully effective. (See Appendix A, page 284.) These washes are similar in effect and use. The second contains fish oil soap as well as rosin and is a more powerful wash in consequence. As caustic soda and fish oil are less easy to obtain than washing soda, the first wash should generally be used. Only when large quantities are to be prepared is it advisable to use the second wash. The rosin used must be the clear brown fir tree rosin imported from Europe. This rosin may also be obtained from the Forest Department at Dehra Dun and Naini Tal.

The washes cost about Rs. 3 per 100 gallons, or Rs. 4 per 100 gallons on estates far from the coast and a railway station.

These washes are for use against scale insects such as brown bug, green bug, black bug, etc., also against green fly (aphis) and similar small sucking insects. They have not the wetting power of kerosene emulsion and so are less effective against mealy bug or other mealy insects. They are excellent contact poisons, useful against a variety of pests. Diluted wash (1 lb. of rosin to 10 gallons of water) is also valuable with lead arseniate, used as a stomach poison, since it protects the

latter from rain and helps it to remain on the plant. The wash has of itself no poisoning effect on cattle or other animals, and may be safely applied at all times. It has also no effect as a stomach poison against caterpillars, etc., and is intended simply as an efficient contact poison against all small sucking insects except the mealy ones.

Tobacco.

Fermented tobacco forms a decoction which acts as a mild stomach poison and also as a contact poison. It requires to be soaked in water to extract the alkaloids and then is best used with the addition of soap. It is a weak insecticide, valuable against plant lice, mealy bugs, soft sucking insects and very small caterpillars, but not so effective as any of the above mixtures. It is obtainable in many parts of India and the wash is best prepared from the stalks and refuse of the leaf tobacco.

Sanitary fluid.

The liquids called by this general name consist largely of creosote oil containing carbolic acid (phenyl). Mixed with water they emulsify, owing to the presence of rosin soap, and in weak emulsion are excellent contact poisons. This is an insecticide not in general use elsewhere but which has given excellent results in India. A strength of one in one hundred of water is excellent against all forms of soft sucking insects, against plant lice, mealy bug, green bug, etc. At a strength of one in sixty of water, it is a powerful insecticide, which kills all but the most resistant sucking insects and has a considerable effect on caterpillars, small grasshoppers, etc. At greater strength it burns the foliage of actively growing plants ; it was used at one in forty against the Bombay locust, killing a large percentage, and at one in twenty killing everyone sprayed, without injury to the hardy foliage of forest trees.

Other contact poisons.

Countless mixtures have been used as contact poisons since these were first tested and a great variety are still in use. In India only what are known in Europe as "summer washes" can be used, which restricts the available number. There is sufficient latitude in the above mixtures to suit every case and no good will be done by discussing the hundreds of mixtures recommended. This applies also to the patent insecticides ; none are yet proved to be as good as the insecticides made on the spot and none have the combined efficiency and usefulness of crude

oil emulsion. Any one requiring a made-up contact poison will find this suitable ; other made-up contact poisons can be purchased ; McDougal's insecticide is an example, which acts solely as a contact poison. It is valuable as a ready-made and effective contact poison, which acts with much the same effect at the same strength as crude oil emulsion, the latter being far cheaper. Both have been thoroughly tested and both can be recommended.

Insecticides are not like patent medicines, requiring only to be applied (or taken), when they do the rest. They must be used in good time ; an acre of mustard that was badly infested with aphis required two hundred and fifty gallons of insecticide to kill every aphis, or three times the amount required to destroy the same aphis at the beginning of the attack on another acre. They must also be applied intelligently and vigorously, with the express object of destroying the insect and not because it is the right thing to do. They must be applied properly, with an understanding of what they are meant for and will effect.

PART III.

INSECTS INJURIOUS TO CROPS.

CHAPTER VIII.

PESTS OF THE COTTON PLANT.

THE cotton plant suffers from a number of insect pests which lessen the vigour of the plant and diminish the actual yield of the lint and seed. These pests are widespread in India, do a great aggregate amount of damage and largely reduce the yield of probably every acre in India; but they are disregarded by the cultivator, who is not aware that he can, by adopting simple measures, obtain a larger yield of finer cotton. These pests include the boll-worms, of which there are three species, two identical in almost all but name and one distinct species; the two beetles that attack the stem; two bugs that attack the bolls; and two caterpillars, an aphis and a leaf-hopper, that attack the leaves. There are in addition a variety of minor pests which are not exclusively pests of cotton and which appear only casually.

The Spotted Boll-worms.

Caterpillars which destroy ripening bolls of the cotton plant and which may be found by looking for such injured bolls before the cotton ripens. They are easy to recognise and readily reared to the imago. The life history is typical of the moths.

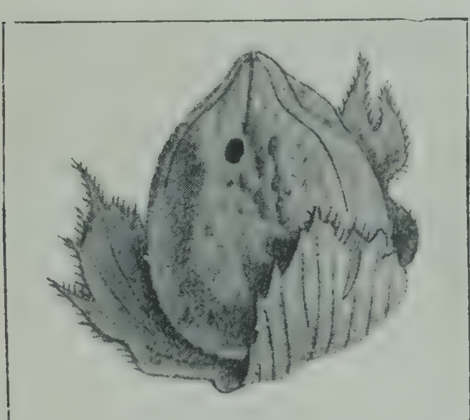

FIG. 98.
Boll containing Boll-worm.

The term boll-worm is in America applied to the caterpillar described in this book as the Gram Caterpillar (see page 144). In India this insect does not attack cotton, its place being taken by the two spotted boll-worms and the pink boll-worm, the latter being discussed separately.

Life History.—Eggs are laid by the moth singly on the bracts, bolls and terminal leaves of the cotton-plant. Each egg is small, not more

Figures. Where a figure is said to be magnified, and a hair line is found beside the insect, this line represents the actual length of the insect as drawn. When there is no hair line, the statement, for example "magnified three times," means that each lineal dimension is three times larger in the figure, the figures being thus actually nine times magnified if we consider the area it covers. A linear magnification of even three is considerable, and in comparing an insect with a figure (in the endeavour to identify the insect with the figure) a good lens must be used; the human eye cannot compare a small insect with its enlarged figure unless the insect is presented to it *at least as large as the figure.* A lens magnifying ten diameters will be sufficient for every insect figured in this volume, but it is impossible to compare insects and the figures unless a lens is used. Where no magnification is mentioned and no hair line occurs, the figure is the natural size.

than one-fiftieth of an inch across, round, of a bluish colour, finely ribbed and marked. Within a few days it hatches to a tiny dark coloured caterpillar, which feeds first on the bracts and flowers or eats straight into the rind of the boll. In the former case it attacks the bolls within a few days. When no bolls are formed, it tunnels down the shoots, commencing at the tip and eating for a considerable distance down the shoot, thus destroying it; normally it cuts its way through the rind of the boll and the developing lint, until it reaches a seed, which it eats. Having destroyed one seed it eats another. If the bolls are small, they frequently drop off, but if a large part of the seeds are eaten, the lint is destroyed and the boll filled with excrement. A single caterpillar will rarely destroy more than one large boll but becomes full-fed in the first. More than one is rarely found in a boll unless small ones enter a boll already tenanted by a large one.

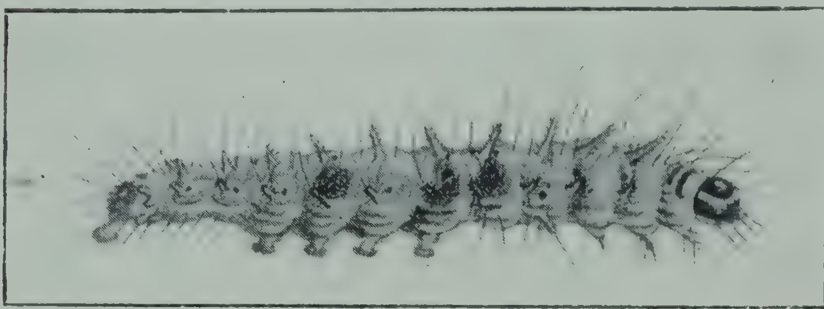

Fig. 99.
Spotted Boll-worm. (*Magnified four times.*)

When the caterpillar is full fed, it leaves the boll and prepares a cocoon of tough grey silk within which it transforms to the pupa. In the black cotton soil of Western India, this is found in the cracks and crevices of the soil. In Cawnpore, Mr. J. M. Hayman states that it is found "on the bolls or bracts, generally between the two," and this is the case also in Behar and the Punjab.

The period of pupation is from 8 to 10 days but may be longer in the cold weather. Eventually the moths come out, pair and lay eggs, each moth laying about sixty eggs. The shortest total life history occupies about one month. Moths are to be found flying in the dusk; during the day they hide in the ground or on the cotton plants. They are not attracted by light. Both species also feed upon *bhindi* (*Hibiscus esculentus*), des-

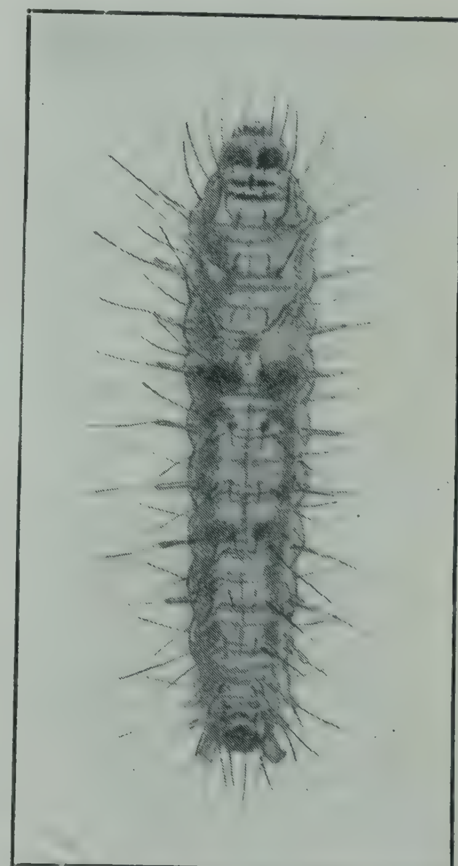

Fig. 100.
Spotted Boll-worm.
(*Magnified four times.*)

troying the fruits or the succulent stems. In Western India these insects are active throughout the winter, where the temperature does not fall so low as in Northern India. From August or September to the following January or February there is abundance of cotton in which they multiply. In places where the temperature falls, as in the Deccan, Northern India and Behar, they hibernate as pupæ, rarely as eggs, larvæ or moths, until March. If cotton-plants are left standing in the field or if bhindi is available, they then find food; if not, they remain dormant as moths or possibly pupæ, until the rains. Where cotton is grown throughout the year, it is continually attacked except in the cold weather. Both species are widely distributed in India and practically range throughout the plains.

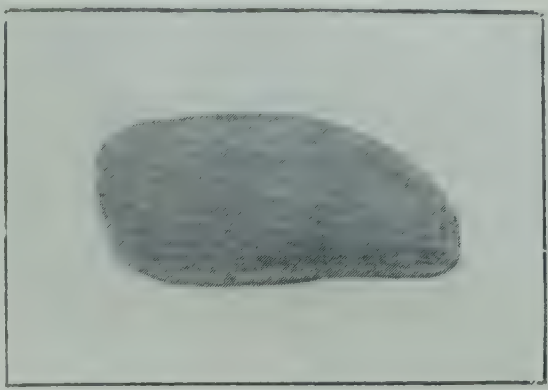

FIG. 101.
Cocoon of Spotted Boll-worm.
(Magnified three times.)

FIG. 102.
Spotted Boll-worm Moth.
(Magnified twice.)

Spotted boll-worms are attacked by three distinct parasites, two ichneumons and one tachinid fly. Of these, one [1] is generally distributed and a very important check on the increase of the insect; the fly [2] has been found in some scattered localities and may be an insect of some importance.

Description.—The moth of the commoner species [3] is coloured with a broad green band extending from the base to the apex of each wing. This green band may be absent, the whole wings being ochreous or buff. The other species [4] has the forewings a bright green. In both species the moth measures a little under half an inch in length, the expanded wings nearly one inch. The lower wings are white, and the under surface of the body nearly white.

FIG. 103.
Spotted Boll-worm Moth.
(Magnified three times.)

[1] 96. *Rhogas lefroyi.* Ashm. (Chalcidæ.)
[2] 99. *Plectops orbata.* Wied. (Tachinidæ.)
[3] 73. *Earias fabia.* Stoll. (Noctuidæ.)
[4] 108. *Earias insulana.* Boisd. (Noctuidæ.)

The caterpillars are short and thick, not more than two-thirds of an inch long when full grown. The colour is very variable, a mixture of white, green and black, with orange spots. The predominant colour may be a dull greenish white, with black marks and small orange spots, or black, with an irregular band of greenish white from head to tail with orange spots on the sides. There are tubercles on each segment, bearing hairs; the orange spots appear only in fairly advanced larvæ and the quite young caterpillars are darker. Legs and prolegs are present, the head is dark in colour and there is a dark prothoracic shield.

The cocoon is less than half an inch long, oval and flattened, made of grey silk closely woven. It has a resemblance to the grey woolly buds that fall off the cotton-plant.

Remedies.—The treatment of this pest depends upon the conditions under which cotton is grown, and the variety of cotton. Certain varieties show a complete or partial immunity to it, but it is uncertain how far any variety will prove immune when grown as a field crop. The varieties now grown as field crops are apparently all attacked. There is only one direct remedy that can at present be advised for general adoption. It is applicable only to cottons which produce a crop of bolls at one time and is ineffective in varieties which continue to produce bolls over a long period. It consists in destroying as many of the caterpillars as possible in the shoots of the cotton or in the first bolls. The first brood of boll-worms is found in the shoots and in the early bolls; the dead shoots are readily seen and destroyed, the attacked bolls are easily found and burnt. There is no loss of crop, as these bolls will never yield cotton, and it is very important to check the first brood which soon becomes a very large second brood if left alone. This method can be carried to the degree of removing all the early bolls.

Another treatment, still in the experimental stage, consists in spraying with lead arseniate when the bolls first form. A preventive measure of some importance is to remove the plants when the crop is picked. It is not uncommon to see stray plants still living in the hot weather after the crop is harvested, which help the pest to increase at a very critical time, especially if showers fall and the cotton makes a little growth.

The importance of bhindi as an alternative food-plant is also great. Where bhindi is grown, the insects can breed in it when cotton is not available. Where cotton is a staple crop, bhindi should not be grown except when there is cotton. It should not be grown in Gujarat, for instance, from February to August, as it helps the pest to increase during the hot weather and early rains, providing a large number of

moths to breed caterpillars which attack the cotton in August and September. Experiments are in progress to use bhindi as a trap crop in or around cotton, in the hope of collecting the insects in that crop which can then be destroyed. The success obtained during the past season justifies the more extended trial of this measure.

The Pink Boll-worm.

Associated with the spotted boll-worms is a slender reddish caterpillar found feeding in the green or ripe bolls. It is easily distinguished from the other caterpillars found on cotton.

FIG. 104.
Pink Boll-worm. (*Magnified.*)

The moth lays a number of small flattened eggs, similar to those laid by the majority of small moths; the eggs are deposited singly on leaves, stalks and bolls, and hatch in a few days.

The young caterpillar is white, with a dark head, and is found feeding on the leaves or on the outside of the boll. It does not immediately attack the boll but bores in through the rind when it has fed for a few days outside.

Like the spotted boll-worms this one feeds upon the oily seeds, eating seed after seed until it has become full grown. As a rule one will be found in a boll but exceptionally several attack the same boll. The full grown larva is of a white colour, with bright pink spots, more slender than the spotted boll-worms and without processes. The larval life varies in duration according to the season but occupies two to three weeks in the active period. The full grown larva forms a slight cocoon of silk, in the boll or on the bracts or leaves of the cotton. In unirrigated black cotton soil this may be found in a crack of the dry soil. The shortest period for

[1] 74. *Gelechia gossypiella.* Saund. (Tineidæ.)

the pupa is from fourteen to eighteen days, after which the moth emerges.

The moth is less than half an inch in length, the antennæ filiform, the palpi upturned, the general colour grey brown with dark blotches and suffusions, the wings with long brown fringes. The moth cannot easily be distinguished from other *Tineid* moths by its appearance alone. Moths fly at night and dusk: they are attracted by light and are readily captured in lamp traps.

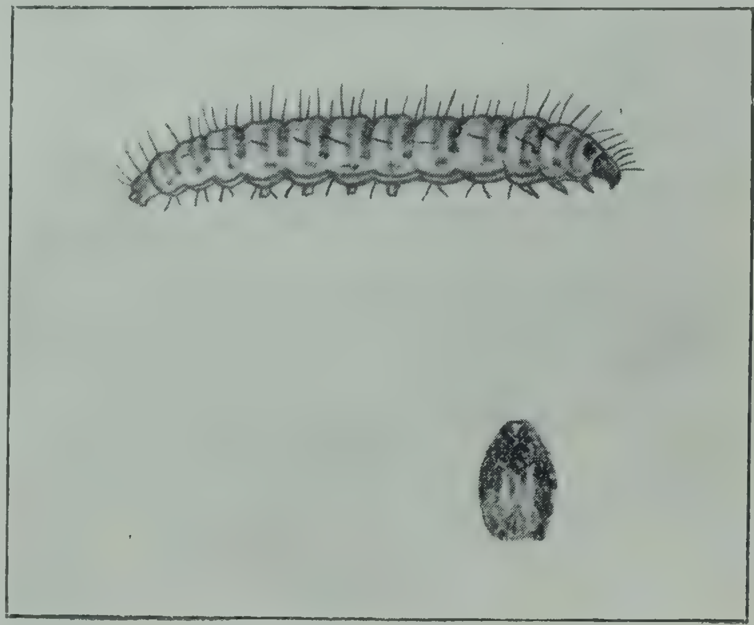

FIG. 105.
Pink Boll-worm Caterpillar and Cocoon, the former magnified, the latter natural size.

The pink boll-worms are most abundant when the cotton forms bolls in October or earlier; the active period is during the rains and after; in many parts of India the larvæ hibernate in the cold weather, but this is not the case for instance in South Gujarat. In Behar the larvæ live through the cold weather in the lint or seed of the cotton, emerging as moths only in March or April; their further activity depends upon circumstances, the moths laying eggs then if cotton is available. There may be a further period of rest during the dry hot months before the rains. Actually larvæ have been found active in all months of the year, but there are two main periods of rest, from November to March and from April to June, depending upon climatic conditions and the supply of food.

FIG. 106.
Pink Boll-worm Moth. (Magnified six times.)

The pest is apparently universal in India, Ceylon, Burma and the Straits Settlements, causing a very large aggregate loss to cotton in India, which may amount to at least one crore of rupees annually. The destruction of the seed, the staining of the lint and the loss of young bolls are the principal forms of damage. So far as is known all varieties of cotton now grown as field crops in India are attacked, the American and Egyptian as well as the indigenous. It remains to be seen whether there are any varieties of cotton immune to the pests, but none have definitely proved so up to the present.

FIG. 107.
Parasite on Caterpillar of Pink Boll-worm.
(Magnified six times.)

Unlike the other boll-worms, this species has not been found attacking plants allied to cotton; its wild food-plants appear to be trees with oily seeds which are widely distributed in India.

Remedies.—The first and most important remedy is to check the increase of the pink boll-worm by plucking off the first crop of bolls if they are attacked. When the first bolls are forming, the first batch of moths lays eggs on them and the boll-worm commences. If left alone these boll-worms will emerge as moths and each lay many eggs. The increase from one pair of moths being large, the second brood is generally a fairly numerous one. Had this first brood been destroyed, it could not have multiplied and destroyed so much cotton later in the season.

The second precaution is the treatment of seed by fumigation or other means to destroy the hibernating larvæ. Fumigation with carbon bisulphide after the seed has been picked over in the sun is the most effective method of freeing cotton from boll-worms. Equally it is important to pick off the bolls which are destroyed on the plant. Leaving on the plants the bolls that are eaten or destroyed assists cotton pests to multiply and increase. It particularly assists pink boll-worms and the cotton bugs. Other methods of treatment, such as the spraying of bolls with lead arseniate and the use of light traps, are as yet only in the experimental stage.

Generally the picking of the first bolls is practically the only method that can at present be advised. When the cotton bolls are formed at one season only and the crop ripens quickly and nearly simultaneously, this method is capable of general application; in the case of cottons that yield slowly and continuously over long periods, it is doubtful if a full crop can ever be obtained or even a reasonable proportion of the crop.

For such cottons the pest may be regarded as a very serious one. Trap crops of annual cottons may effect something in the case of valuable tree cottons, if such trap crops are used intelligently, but this method also is only in the experimental stage.

The Cotton Leaf-Roller.[1]

A slender caterpillar of a pale greenish colour with a dark-coloured head, which lives upon the lower side of the leaf of the cotton and bhindi plants, folding the leaf over and eating it; it is easily recognised and is a very common pest of these plants. As a cotton pest it is of some importance, especially in the early life of the plant, and needs to be vigorously checked from the outset if it is not seriously to injure or delay the crop.

Life History.—The female moth, flying in the dusk or at night, lays her eggs on the lower side of the leaves, one here, one there; sometimes one on each leaf, often two or more. The eggs are small, round greenish objects, about the same size as the head of a small pin. They hatch in a few days and a tiny slender caterpillar comes out. The young caterpillar feeds upon the leaf gnawing the lower side; it spins threads over and around itself as a protection and soon sheds its first skin and grows larger. It then continues feeding upon the leaf; as a rule it turns the edge of the leaf over in a fold

FIG. 108.
Cotton leaves, rolled by the Cotton Leaf-Roller.
(The left hand leaf contains two caterpillars.)

[1] 37. *Sylepta derogata.* Fabr. (Pyralidæ.)

and binds it down with silken threads, living safely within this fold. As it grows larger, it binds more and more folds together, forming a kind of nest of rolled leaf in which it feeds. In those varieties of cotton with a large leaf, the whole or a great part of the leaf is thus tied together and if the caterpillar eats much at the base, the leaf withers. In the case of bhindi or of varieties of cotton with smaller, divided leaves, the leaf may be simply eaten, not folded together into a compact bunch. Especially is this the case in the smaller leaved cottons, where the caterpillar lives in the top leaves of each shoot and binds them all together. These folded leaves are fairly characteristic of this insect and if opened will be found to contain one or several caterpillars, with a mass of black excrement in grains. [Another caterpillar (the bud caterpillar No. 80) lives only in the top leaves of the shoot, binding them into a very compact mass, which withers and turns dark; one can readily distinguish this by the appearance of the caterpillar, of which only one lives in each mass; it is small, not more than half an inch long, of a distinct opaque dull green colour, not shiny and transparent as is this leaf-roller (see page 99).]

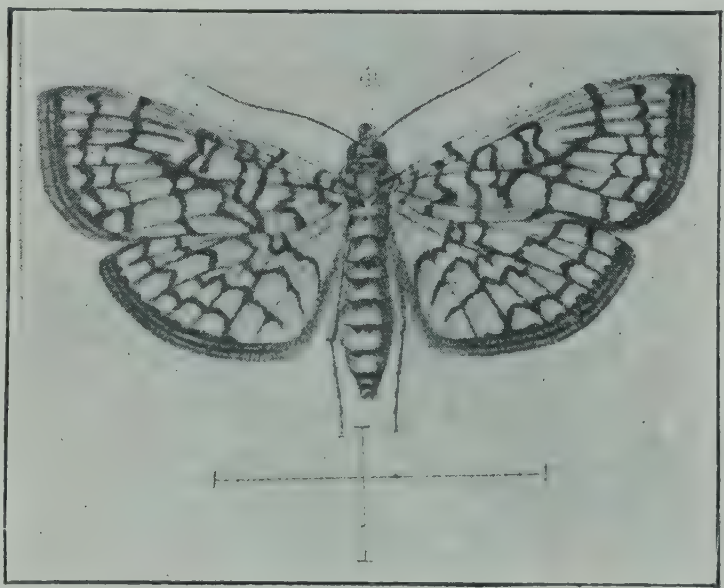

FIG. 109.
Moth of Cotton Leaf-Roller. (*Magnified.*)

The leaf-roller grows to a length of over one inch; it is slender, the body transparent with a faint greenish tinge, and the dark contents of the alimentary canal showing through the skin; the legs are dark, and easily seen, the sucker-feet long and slender. The head and neck are dark brown and there are a few long slender hairs on each segment.

After two to three weeks' life as a caterpillar, the last skin is shed and the chrysalis is formed. This is shiny chestnut brown, with no legs or means of locomotion, about half an inch in length. It lies among the twisted leaves suspended by the threads made by the caterpillar, and is easily found by untwisting the rolled-up leaves. It lies motionless for eight days and then opens, the moth emerging.

The moth is of a whitish colour, with a faint yellow tinge, the wings with many fine dark lines, forming an irregular pattern. It is less than

one inch in length, measuring one and a half inches across when the wings are open. It is very easy to rear and recognise; the brown chrysalis, if left in a box, will yield the moth in a few days and the moth cannot easily be mistaken for any other moth that lives upon cotton. The moths fly about the fields in the dusk, lying hidden among the leaves during the day. After coupling, the female lays eggs and the moths die.

The whole life of this insect occupies from three to four weeks, so that one brood succeeds another rapidly during the warm weather. There are three broods at least in cotton before the cold weather and as each moth lays many eggs, the pest increases rapidly. With the advent of the cold weather, the pest disappears. It is not known to be active during the winter months either in Gujarat or in Behar. It hibernates during the cold weather, reappearing with the rains or rarely before. It is not, therefore, found after November and is a pest to cotton only up to this month.

The food-plants include both cotton, holly hock and "lady-finger," or bhindi (*Hibiscus esculentus*). Possibly there are other wild plants on which it can feed. As the latter plant is grown during the rains as a vegetable, the moths that come out in the early weeks of the rains can lay eggs on it and so there may be one or two broods before it attacks the cotton. It also breeds during the hot weather if plants are available. To both plants it is destructive simply from the damage caused to the leaves. Where it is abundant and strips the plants, it may prove a serious pest, the full yield of cotton not being obtained. One of the common parasites, a tiny black fly, lays its eggs in the caterpillars; the eggs hatch to grubs which feed on the caterpillar and finally come out, to form a small egg-shaped white cocoon on the plants; the caterpillar dies and this insect does much to check the increase of the caterpillar.

Remedies.—The pest is not a very easy one to destroy on cotton, and the first consideration must be to prevent its occurrence as far as possible. As the pest comes from bhindi, the best thing is to grow no bhindi at all within reach of the cotton or to grow it in the young cotton plants and use it as a trap. The indiscriminate growing of bhindi where cotton is also grown is the surest way of helping the pest to attack the cotton. Bhindi should either not be grown at all until November, so that the pest may have no food-plant on which to increase, or should be grown carefully as a trap crop for the pest. In the latter case, if it is sown between the cotton, it will come up more quickly and the caterpillars will be found first upon it. The caterpillars must then be destroyed and the bhindi plants too, as soon as the cotton is large enough to attract the moths to lay eggs. Two months or ten weeks would probably be

the time during which the bhindi should be allowed to grow, after which it should be removed and destroyed with all the caterpillars and chrysalides on it. Some will attack the cotton and then can be removed by plucking all attacked leaves and burning them. This simple method should be applied when the bhindi is removed, if the latter is used as a trap, or as soon as the pest is seen on the cotton. It serves to destroy the first brood on the cotton and so to check the pest from the beginning.

In bad cases of attack on cotton, spraying with lead arseniate is the radical remedy, and where some varieties are grown experimentally, this should be done. Where cotton is grown on a large scale, the pest does little harm as it has so wide a range and does not gather on particular plants. But where cotton is grown on a small scale, there may be so much of the pest as materially to lessen the vigour of the plants, and in this case spraying with lead arseniate is necessary. As a rule, the simple remedy of picking off the affected leaves as soon as they are seen is the only remedy necessary. If done in time, it is entirely effective early in the season.

The moth has a very wide distribution over the East, from West-Africa to Siberia and Australia. It is not recorded as a pest outside India, except from East Africa and doubtfully from the Straits Settlements.

The Cotton Bud Caterpillar.[1]

A small caterpillar which lives on the top of the shoot of the cotton plant, binding the leaves together into a small compact knot which turns

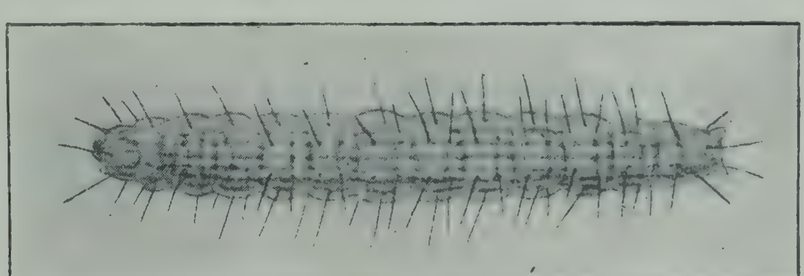

FIG. 110.
Cotton Bud Caterpillar. (Magnified four times.)

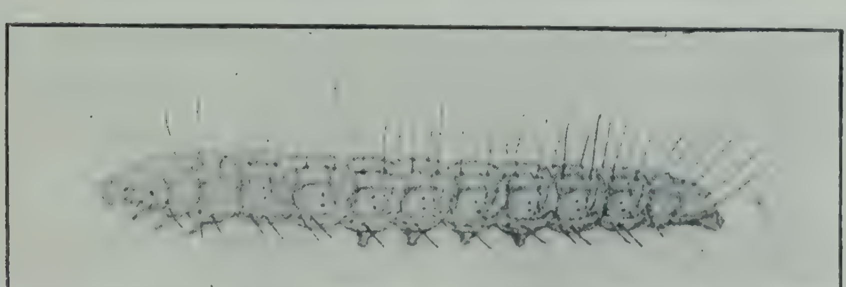

FIG. 111.
Cotton Bud Caterpillar. (Magnified four times.)

[1] 80. *Phycita infusella.* Meyr. (Pyralidæ.)

brown. This pest is easy to recognise from the twisted leaves at the end of the shoot and their withered appearance.

The caterpillar is a small opaque green one, with faint longitudinal lines of brown pigment visible only when examined with a lens. It feeds upon the cotton bud and on the leaves at the tip of the shoot, webbing these together with threads. The small brown pupa is found within the twisted leaves. The moth is less than half an inch long, the antennæ swollen beyond the basal joint, the palpi upturned; the thorax and basal half of the wings are grey, the apical half being darker. It flies in the dusk and is not readily noticed. The caterpillar is found on the cotton from August to November, after which it hibernates. When abundant, the plant grows short and bushy, and in many cases the insect does good by effecting an even pruning. It is a pest only when abnormally abundant.

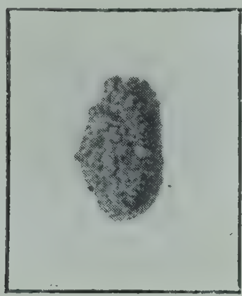

FIG. 112.
Cocoon of Cotton Bud Caterpillar, with adhering soil.

Indigenous cottons similar to the Broach-Deshi, Goghari, etc., are attacked; American and tree cottons appear to be immune. The pest is apparently widely spread in India but nowhere seriously destructive. It is very easily checked by pulling off the little dried knots of leaves and burning them with the larva or pupa inside. Spraying with lead arseniate also checks it but is not generally necessary. The pest is one that is on the whole of little importance, and generally needs to be checked only on experimental farms where the cotton plants are required to come to their full normal vigour. Parasites keep it in check to some extent. Where the mealy bug attacks cotton, the two pests are found together, and often the bud caterpillar is confused with the caterpillar which feeds upon the mealy bug.

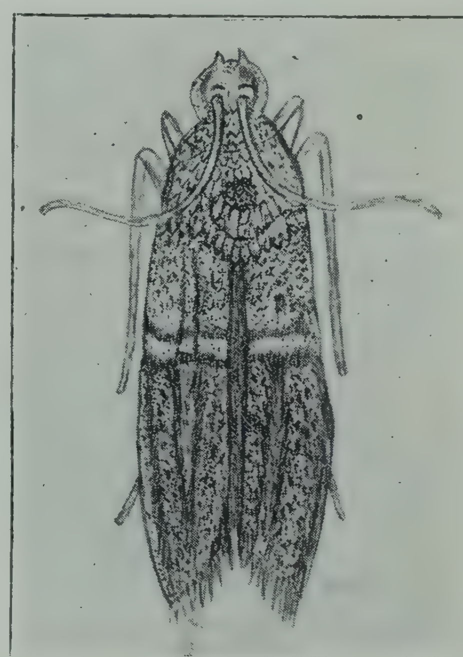

FIG. 113.
Moth of Cotton Bud Caterpillar. (*Magnified five times.*)

The Cotton Stem Borer.[1]

During the growth of cotton plants, from the time the first flower buds are formed until the bolls are picked, single plants are found to

[1] 60. *Sphenoptera gossypii.* Kerr. (Buprestidæ.)

wither, turn yellow and die, apparently without cause. If such plants are pulled up and broken across at the crown, it will be found that the centre has been eaten out, a round tunnel extending up and down the thickest part of the stem. Possibly the insect causing this damage will be found inside the tunnel and there can then be no doubt as to the identity of the insect. No other insect is known to attack cotton in this way in India and if such bored cotton stems are found without the insect, search for other withered or dying plants will probably reveal a plant with this insect at work.

Life History.—The grub enters the stem near the crown, hatching from an egg laid there by the beetle. It bores into the stem, feeding upon the tissues as it goes, and making a neat round tunnel up and down the centre of the stem. One grub inhabits a cotton plant and its tunnel sooner or later destroys so much tissue that the plant dies. The grub is white, in length up to one inch, with a slender body, very much swollen into a round, slightly flattened bulb at the front end. The head is small, in front of the swollen thorax, and has powerful jaws with which it gnaws away the wood. Legs are absent and the bulbous swelling fits the burrow in such a way that the larva can move by muscular contractions and expansions of this part.

When full grown the grub eats a hole almost to the outside, leaving the bark intact, and turns to a chrysalis within the burrow. The chrysalis is white, becoming dark before it emerges, and the legs, wings and antennæ of the future beetle may be seen folded against the body. It lies motionless within the burrow whilst the

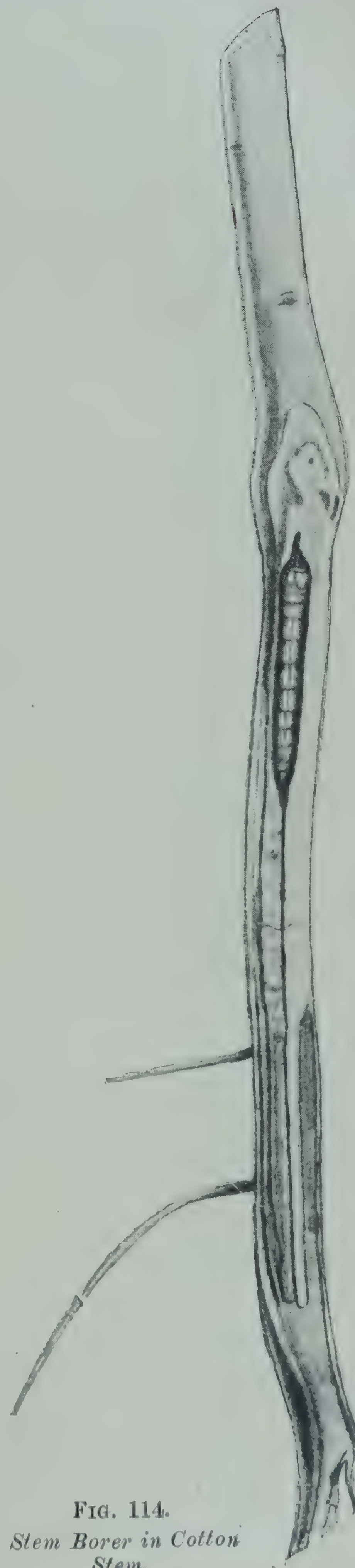

FIG. 114.
Stem Borer in Cotton Stem.

beetle is gradually formed. The beetle that emerges is of a dark bronze colour, hard, with legs, wings and antennæ. It measures $\frac{1}{3}$rd of an inch in length and is recognisable by its colour, its size and its truncated appearance in front.

It emerges through the thin bark left by the grub. Having mated, the female beetle lays eggs and dies.

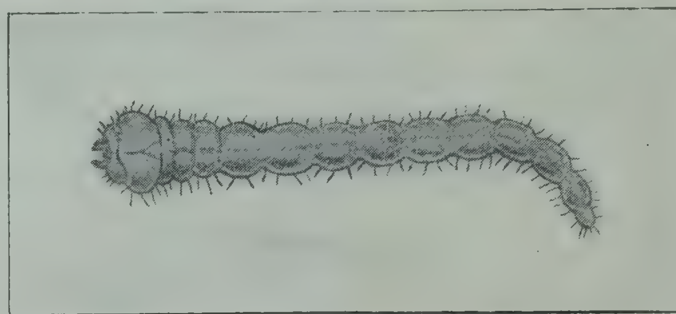

Fig. 115.
Stem Borer Larva.

These beetles are not easily noticed in the cotton fields. They fly actively and are sometimes found on the leaves of the plant. There may be as many as four irregular broods during the cotton season; the first is a small one and only few plants are destroyed; the second is a large one, the beetles of the first brood laying many eggs; the third brood is large but is liable to suffer much from parasites; the fourth brood may be very small and is not important, the cotton having been picked before its arrival. These broods are quite irregular and not well marked, since the beetles do not all come out at once. The destruction to the plants will be noticed when flowers come out; it may be seen earlier, depending upon the growth of the cotton.

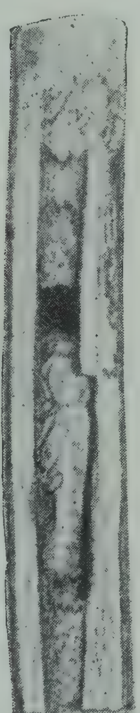

Fig. 116.
Pupa in stem.

Fig. 117.
Stem Borer Pupa.
(Magnified three times.)

Fig. 118.
Hole where Beetle emerges.

Remedies.—The pest is easily checked if all the withered plants are removed regularly and systematically. It is easy to see withered plants, which can be collected and destroyed before the beetle escapes from them. There is no other simple remedy. It may be found possible to apply a dressing to the plants that will keep off the beetles and prevent egg-laying, but the remedy above given is so simple and thorough, if carried out from the first, that there is no reason to spend money in preventing the first brood from coming. It is better to let it destroy a small number of plants and then make sure of catching it in these plants. Two parasites lay their eggs in the grubs of this beetle in the cotton stem, which check it to a slight extent. It is better not to destroy these parasites if they are present in the cotton stems, and this may be effected thus. Place all the stems which are collected in a box or barrel with the lid covered with thin cloth, securely tied down. The beetles and parasites will hatch, the latter being flies easily distinguished from the bronze beetles. The box can be examined periodically and the parasites, if any hatch, allowed to escape. The beetles on hatching will lie motionless in the box and will not attempt to escape if the cloth is quickly lifted, whilst the parasites are active creatures which will fly out of the box at the first opportunity. The parasites will then go to the cotton fields and seek for grubs of the beetle in which to lay their eggs.

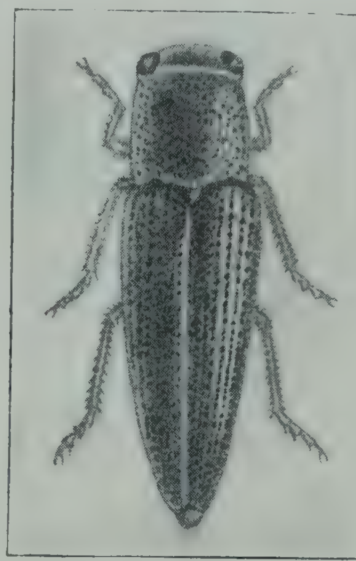

FIG. 119.
Stem Borer Beetle.
(Magnified five times.)

This insect is common in Gujarat, the Deccan, the Central Provinces, and parts of the Punjab. It is rare in Behar and is apparently not so universal a pest as the other insects that attack cotton. There is no record of its occurrence outside India.

Cotton Stem Weevil.[1]

A small white grub found tunneling in the stem or branches of certain races of cotton; the grub is small, less than one quarter of an inch long, distinct in appearance from the stem borer.

This pest has been found only in Behar and has not been under observation for any length of time. The small white grub feeds on the tissue of the cotton stem, making twisted galleries which it fills with

[1] 142. (Curculionidæ.)

excrement. The grub is white, legless, not conspicuously swollen in front. It transforms in the burrow to a small white pupa without covering. From this a small weevil emerges, in length about one-eighth of an inch, of a brown colour with black and whitish marks. The insect has a slender curved beak.

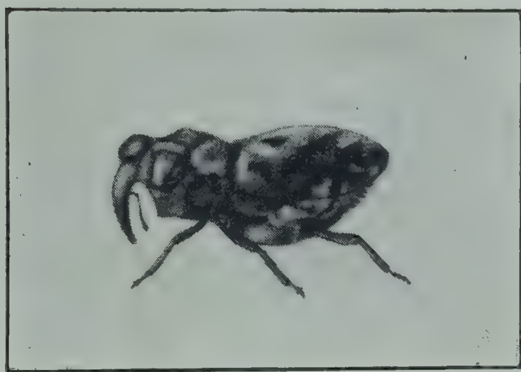

FIG. 120.
The Cotton Stem Weevil.
(*Magnified seven times.*)

The weevil is so small and its flight so quick and active that it is not easy to find in the field. They may be found coupling on the cotton plants prior to egg-laying, but are not likely to be seen or recognised. As a result of the attack of this pest, the cotton branch dies or the stem of the cotton plant swells and in a high wind breaks. The peculiar swelling of the base of the stem of the Broach-Deshi cotton plant is a symptom of this pest, and though the plant lives, it may be destroyed in the first high wind. In Behar, the Broach, Goghari and other Bombay-Deshi cottons were attacked in the stems, the Egyptian cottons seriously injured in the same way and certain varieties of tree cotton (*Caravonica* and others) attacked in the branches. Other tree cottons and many indigenous cottons were on the whole exempt from attack. Once infested the plant is doomed and only preventive measures are effective. Experiments with trap cottons and other trap plants are in progress, and further investigation may reveal some method of checking it. The pest is unlikely to occur only in Behar and may be looked for in other parts of India.

FIG. 121.
The Cotton Stem Weevil.
(*Magnified seven times.*)

The Red Cotton Bug.[1]

This insect is the most familiar insect pest of cotton occurring generally in India, attracting attention rather from its vivid colouring than its destructiveness. It is almost identical with the Red Cotton Stainer of the United States and West Indies. The full grown insect measures a little more than half-an-inch from the head to the tip of the wings. Red is the predominant colour, the eyes, the antennæ, a spot on the

[1] 69. *Dysdercus cingulatus.* Fabr. (Pyrrhocoridæ.)

scutellum and on each wing being black, the apex of the wings absolutely black and forming when folded a black diamond on the upper surface.

FIG. 122.
Bug mistaken for Red Cotton Bug.
(From Distant.)

FIG. 123.
Red Cotton Bug.
(Magnified.)
(From Distant.)

FIG. 124.
Bug mistaken for Red Cotton Bug.
(From Distant.)

There are white transverse lines on the lower surface of the body and a tiny white ring behind the head ; the long sucking beak lies between the legs. The insect is not likely to be confused if carefully examined, but there are other bugs which have a generally similar appearance, though distinct markings.

Life History.—The eggs are laid in a loose mass under the surface of the soil, usually in a crack or depression, which the female covers with earth after depositing the eggs. Each egg is round, of a light yellow colour ; between fifty and sixty are laid by each female. In less than a week the eggs hatch to small active red insects ; wings are not present, the upper surface of the abdomen being red, with a central row of black spots and a row of white ones on each side. In other respects the young insect is similar to the full grown winged insect.

The young moult periodically and grow larger. After the third moult the wings commence to appear as small back lobes on the base of the abdomen. These grow larger at each moult ; there are, as a rule, five moults in all, the insect appearing with perfect wings after the fifth.

The male is slightly smaller than the female ; these couple and the females may then be recognised by the swollen abdomen.

The red cotton bug also attacks the bhindi plant (*Hibiscus esculentus*) and the silk cotton tree ; enormous numbers are found when the latter is fruiting in April and it breeds extensively at this time. On cotton it feeds on the leaves or stems, but especially on the seeds in the green or ripe boll. It may be found clustered on the bolls, the beak firmly fixed, sucking out the juice. Where either cotton or bhindi are

plentiful, the insect becomes very abundant, increasing rapidly in warm weather. This insect has also been reported as attacking the flowers of *Hibiscus* at the Saharanpore Botanical Gardens. There are no definite broods, insects of all ages being found together. Reproduction ceases if food is not abundant, the mature insects alone being found. This may also occur in the cold weather, though it is not invariable, and in Western India all stages may be found in the cold weather.

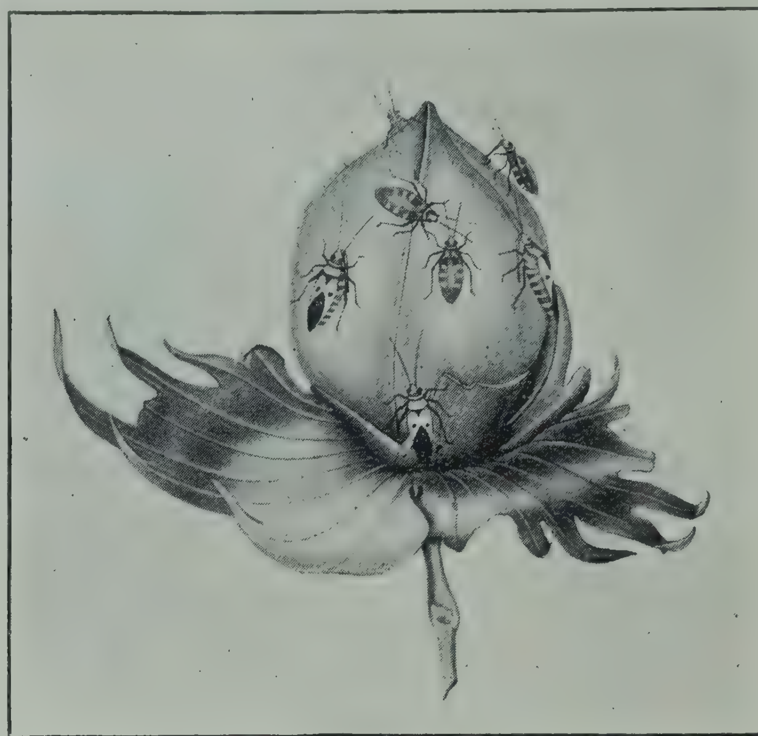

FIG. 125.
The Red Cotton Bug.

If the insect becomes abundant, it weakens the plant and also destroys the seeds. This is the principal damage it causes to cotton, one that is not attributed to the right cause in most cases, as there may be nothing to show what injured the seeds when they are picked. The sucked out seeds are useless for either sowing or for oil extraction, and there may be a very considerable loss from this cause. If the boll is open and the insects congregate among the lint to reach the seeds, the lint may be stained by the excreta, and this form of damage is more readily detected.

Remedies.—Many methods of dealing with this insect have been suggested, most of them impracticable. The insect being large and vigorous, insecticides require to be very strong in order to kill it, and this damages the cotton in some cases. A simple method of destroying it in large quantities is to collect the insects by hand. Each cooly has a small grain winnow (soop) and a kerosene tin with a small quantity of kerosene. The insects are shaken off the plant with a smart tap into the winnow; the winnow is then jerked and the insects fall into the lower upturned portion, from which they are thrown into the kerosene tin. The method is extremely simple and readily understood. Very few insects escape from the grain winnow, and once in the tin their death is certain. The pest is so readily checked by this means that it need never increase excessively. Where seed for planting is obtained from fields

infested with this bug, the seed should be pickled in a mixture of cow-dung, clay and water, and then thrown into water, when the sound seed sinks, the worthless seed floating (see page 287). The red bugs are infested with the maggots of a large *Tachinid* fly, which slowly destroy their host and thus form a check on the increase of the bug.

The insect is common throughout the plains in the jungle and in the fields. It hibernates in many parts of India where the temperature falls considerably and is found in hiding as an imago during the cold weather. Where the climate is suitable it is active throughout the year.

The Dusky Cotton Bug.[1]

This insect is well known as a pest to cotton in many parts of India. Though small and insignificant in appearance, its presence in great numbers in the open bolls of cotton has brought it into notice. It has been reported as sucking green bolls and injuring the lint and seed. The insect is found upon the cotton plant, especially in the bolls that open prematurely after they have been eaten by the boll-worm. Large numbers of small brown insects run out of such bolls when they are handled and either fall to the ground or, if they are full grown, fly away.

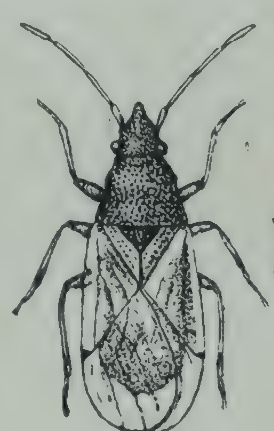

FIG. 126.
Dusky Cotton Bug.
(*Magnified.*)
(*From Distant.*)

The life history in the cotton boll is very simple. The eggs are laid in the lint close to the seed; each egg is cigar-shaped, about one mm. long ($\frac{1}{25}$th inch), of a bright yellow colour, when first laid. They are laid in batches of 6 to 10 at a time, and egg-laying extends over some weeks. Before hatching the egg turns a bright orange and the emerging insect is the same colour. The newly-hatched insect is about $\frac{1}{10}$th inch long, with three pairs of legs, the usual four-jointed antennæ and an enormous proboscis which stretches from the head to beyond the end of the tail. With this it is able to pierce the cotton and extract food from within the seed. During the next week it grows larger, shedding its skin at short intervals to allow of expansion. The colour gradually alters to a deep reddish brown, darkening at each moult. At the fourth moult the wings appear, as small growths on the upper side of the body. At the fifth moult the wings are large but not fully developed, appearing in their full size after the sixth moult when the insect is mature. The perfect insect is nearly black, one-sixth of an inch in length, with the

[1] 5. *Oxycarænus lætus.* Kirby. (Lygæidæ.)

transparent wings folded over the back. The female is slightly larger than the male but otherwise outwardly similar.

The whole period from the egg to the perfect insect's emergence is twelve days. The mature insects lay eggs and then die. They may live for many weeks before they lay eggs and if food for their young is not available, they wait. Probably they pass the dry weather in the adult condition if no food is available for them, as they may be found on the plants of cotton, etc., at different times of the year. In the cotton season their increase is rapid, the eggs being laid in the cotton bolls. At other times they will lay eggs in the pods of the bhindi (*Hibiscus esculentus*) and possibly of other malvaceous plants, or wait until egg-laying becomes possible.

The amount of destruction caused by these insects varies with circumstances. Where there is abundance of worm-eaten bolls, the insects live in these bolls, which open early. They are then credited with the damage done by the boll-worm, as they are the only insect found when the boll is picked. The actual destruction to the crop in this case is small. Where there are no bolls attacked by worm, they attack the bolls as they open and are responsible for damage. The seeds are sucked, the lint is dirtied, and they increase very rapidly in such bolls.

The simplest method of treating them is to shake them off the bolls into a vessel containing water and a small quantity of kerosene. The early ripening bolls contain them in great numbers and by shaking these bolls over a tin pot of kerosene and water, they will be killed in large numbers. Worm-eaten bolls, with the insects inside, may be picked off and removed in a bag. There would be a far smaller number of the insect in cotton fields were this done, and the method of testing cotton seed (page 287) should be applied to seed from infested fields. This method of picking off and shaking the bolls may be tedious and long, but it is the only practicable method as a rule. On farms the work can be better done with a spraying machine. It is extremely important to check the pest at the outset when it is breeding in the first opened bolls, and very much better cotton will be obtained when the cultivator takes an interest in his cotton pests and attempts to check them. What is said about testing cotton seed infested with Red Bug applies also to seed sucked by the Dusky Bug.

The pest is generally distributed in the plains, though rarely abundant.

The Cotton Leaf Hopper.[1]

Among the common insect pests of cotton, the least noticeable is a tiny green fly, which lives on the cotton leaves and flies or leaps out

[1] 82. (Jassidæ.)

when the plant is shaken. It is distinct from the cotton aphis since it is very active, both leaping and flying; when it is plentiful, great numbers leap from the cotton plants when they are shaken or disturbed, and this is the simplest way in which to detect the pest. The insect belongs to the family *Jassidæ*, leaf hoppers, of which great numbers live in grass or almost any vegetation; they are so small as to escape notice. The eggs are laid in the tissues of the plant, and the young that hatch are similar to the full grown insect but wingless and smaller. The food consists of the sap of the leaves, which is extracted by means of the slender sucking apparatus which forms the mouth. The species attacking cotton may be found at all times of the year both in grass and in cotton. Healthy vigorous cotton is less attacked than weak unhealthy cotton; fewer insects are to be found on vigorous cotton plants and the leaf hoppers prefer to live on unhealthy plants. As a pest, the insect has been found only on cotton growing under unsuitable conditions. In 1904, there were plots of healthy cotton and of cotton that had suffered from the drought, growing side by side in one of the Government experimental farms. Few insects could be found in the former, whilst the latter contained enormous numbers. This was observed also in Behar, where cotton was being tried and suffered heavily from the excess of moisture. The absolutely backward cotton was infested, the vigorous cotton was practically free. As a pest then it will be found attacking weak cotton; the result of the attack is that the leaves curl, become discoloured, wither and fall off.

FIG. 127. *Cotton Leaf Hopper.* (*Magnified.*)

The pest is apt to kill cotton that is struggling against bad conditions. It appears to attack the larger leaved tree cottons and American varieties more than the smaller leaved Broach-Deshi and Goghari cottons, but will attack every variety if the plants are in bad condition. Evidently this insect cannot rank as a general pest since it will not attack healthy cotton. It is a serious pest in the experimental farms where introduced varieties are being acclimatised; it has also been a pest to many varieties of the American and Egyptian cotton grown in Behar during the wet months. It has been successfully checked by spraying with crude oil emulsion, at the rate of 1 in 50 of water. An acre of badly infested Goghari cotton treated with a Success Knapsack machine requires 100 gallons of wash, costing Rs. 3-8, and one day for application. A large amount of wash must be used since it is desired to spray the insects as they come out of the plants in a cloud, and not to spray the plant alone. This is a simple and effective remedy; no other appears likely to be so

successful. Where it is necessary to help a struggling crop through a bad season, spraying of this kind will be a necessity. When the plants become stronger, they will not show the disease, and will not be impaired by it.

This insect is known from Gujarat, Nagpur, Cawnpore, Lyallpur and Behar at the present time. It will probably be found wherever cotton is grown in India.

Cotton Aphis.

Small sucking insects found in abundance on the shoots and leaves of the cotton plant; they are about one-twentieth of an inch long, coloured in dull yellow or black, and have two short processes projecting from the upper surface of the abdomen. This pest is one of the common plant-lice discussed in a later section and has a similar life history. The colonies found on cotton consist of female insects, which produce living young. There is no metamorphosis; the young are born alive and are all females. After a few days they in turn commence to produce living young ones. Two kinds of females may be seen, unwinged yellowish ones and winged black ones. The latter fly from plant to plant and

Fig. 128.
Winged female. (*Magnified ten times.*)

spread the pest over the field. As a rule the young and the unwinged females move but little, feeding in compact colonies on the underside of the leaves or on the shoots; they extract the sap from the plant, making it weak and sickly. The insect appears in the rains and, if cotton plants are available, remains on them until the weather becomes very dry, often until the end of the cold weather. In cloudy weather the winged ones fly far over the field and found new colonies. Hence it is that after the

[1] 8. *Aphis gossypii.* Glov. (Aphidæ.)

cloudy weather, aphis becomes more abundant and suddenly appears over large areas.

Fig. 129.
Cotton Aphis, winged female.
(Magnified fifteen times.)

Plant-lice excrete a sugary liquid, which, falling on the leaves below, dries to a sticky coating. This appearance on the leaves is a sign of the pest and is familiar to cultivators.

Many insects attack the cotton aphis and are very important checks upon it; these are described in a later section under beneficial insects. These insects should be familiar to all who grow cotton and should not be destroyed in error as injurious insects.

The treatment for cotton aphis lies in spraying with a contact poison, doing this when the first colonies appear on the cotton and not delaying until with cloudy weather they spread over the whole field. If cultivators were familiar with aphis and checked it as soon as they first saw it, it would never become so serious a pest. Without this, large areas may in cloudy weather become affected, and though the pest is principally one on farms and experimental cultivation, it is also an important field pest.

Minor Pests.

There are a number of insects which attack cotton casually, doing as a rule no harm but possibly injurious in unusual seasons. The White Weevil[1] is a small beetle, of a dull white colour, found upon the leaves of all varieties of the cotton plant almost throughout the year. It bites the leaves of the plant, eating in from the edge. It is most conspicuous from

[1] *Myllocerus maculosus.* Des L. (Curculionidæ.)

July to October, but has been found at all times. The life history is completely unknown and is apparently not passed in the cotton plant. Special treatment is not required for this pest, which is easily destroyed by shaking it off the plant; it has a habit of falling to the ground when disturbed and "shamming dead." The Green Weevil[1] is also a pest of cotton, eating the leaves in the same manner. This insect is larger than the White Weevil, of a dark colour but clothed in metallic green scales, which give it a peculiarly brilliant appearance. It is common in Behar and, like the White Weevil, is found also on bhindi, maize and other crops. The Cotton Caterpillar[2] is a green caterpillar, which is found on the cotton leaf; it walks after the fashion of the true looper caterpillars, hunching up its body at every step, but is actually a "semi-looper" with three pairs of sucker-feet on the abdomen. The caterpillar is marked with fine white lines and grows to a length of one inch and a quarter. It eats the leaf, making large holes, and finally pupates by turning over the edge and folding it down. The moth emerges after eight days. This pest is not common, is found only during the rains and feeds also on bhindi and other plants.

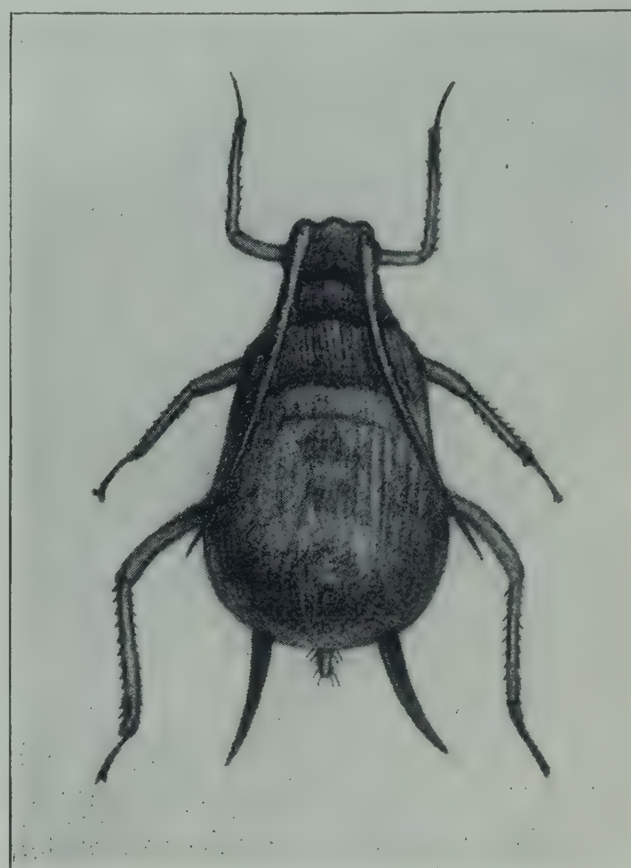

FIG. 130.
Cotton Aphis, unwinged female.
(Magnified fifteen times.)

Another semi-looper found on cotton has but two pairs of sucker-feet on the abdomen and a swelling on the upper surface of the body on the first abdominal segments and the tail. It feeds on the cotton leaf and eventually comes out as a white moth[3] with dark markings. Like the last this is not usually injurious but is likely to be mistaken for a serious pest.

Hairy caterpillars which at times ravage large areas of crops also attack cotton and may do much harm. In Behar, the common hairy

[1] 188. *Astycus lateralis.* F. (Curculionidæ.)
[2] 115. *Cosmophila erosa.* Hubn. (Noctuidæ.)
[3] 152. *Tarache catena.* Sow. (Noctuidæ.)

caterpillar [1] is found in abundance on cotton throughout the rains if other crops fail it, and this applies also to the Hairy Caterpillar of Gujarat.[2]

The very common Red Leaf Beetle [3] is found on cotton but does no harm. The Cotton Mealy Bug is a peculiar species which is found on the top of the shoot; the shoot swells and twists, forming a hard gall-like mass and stunting the growth of the plant. Only some varieties of indigenous cottons are affected and the pest is not widely spread. It requires to be destroyed by picking the twisted shoots, or by spraying, as it interferes with the normal growth of the plant.

The large spotted grasshopper [4] is one of the few grasshoppers that is commonly found feeding on this plant. Germinating cotton suffers from the ground grasshoppers and weevils which attack germinating seeds as they push leaves above the ground (see page 220). The ryot sows his cotton so thickly that no damage is done as a rule, but tree cottons and other cottons sown far apart will be eaten if the field is very clean. It is advisable to sow some such crop as maize between the cotton or to leave the final weeding till the cotton has formed two leaves, as the insect then has other food and spares the cotton.

[1] 136. *Diacrisia obliqua.* Wlk. (Arctiidæ.)
[2] 220. *Amsacta lactinea.* Cr. (Arctiidæ.)
[3] 11. *Aulacophora foveicollis.* Küst. (Chrysomelidæ.)
[4] 49. *Acridium æruginosum.* Burm. (Acridiidæ.)

CHAPTER IX.

PESTS OF RICE AND WHEAT.

THE area occupied by these crops is so large that it has not been possible to study adequately their pests in detail. The four chief insects that attack rice and one that attacks wheat are described. There are in addition many insects which appear occasionally, especially those caterpillars which attack rice. In general these are not formidable nor sufficiently abundant to make any impression on the very large area of this crop. The method recommended for dealing with the Rice Grasshopper should in many cases give good results against these Rice Caterpillars.

Wheat appears to suffer from few pests; the stem-borer is a specific pest of wheat, cane, etc. The wheat aphis is a serious pest dealt with under the heading "Green Fly and Plant Lice" (page 237). Young wheat suffers from ground insects as do other young rabi crops. Many pests of wheat probably remain to be discovered and any extension of the area under this crop to fresh districts will probably produce new pests.

The Rice Hispa.[1]

A small blue-black beetle, covered with spines, which feeds upon the leaves of rice; an infested field becomes yellow, the leaves dying and the plants withering. This pest is a familiar one to cultivators of Bengal and Assam, known by many vernacular names. The small flattened beetle is easy to recognise and the peculiar effects of the attack are fairly characteristic.

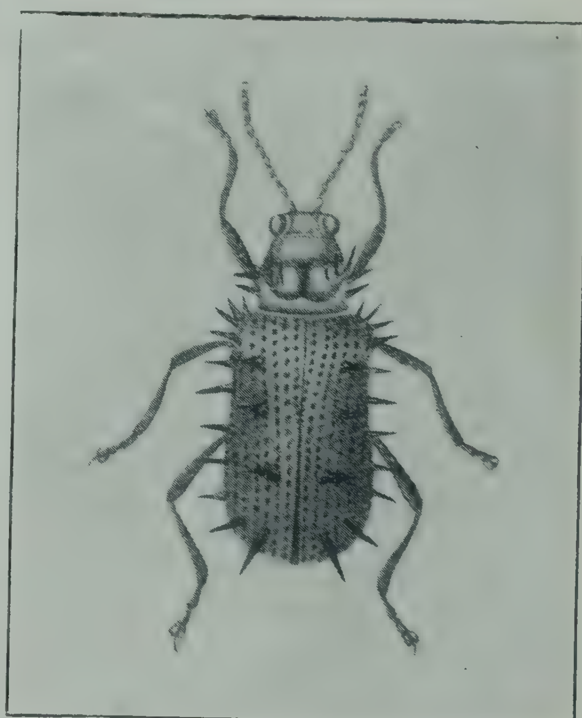

FIG. 131.
The Rice Hispa. (Magnified seven times.)

Life History.—The eggs are laid singly, each egg being inserted in the tissue of the leaf, almost exposed and easily visible. The egg is oval, about one-thirtieth of an inch long, and when in the leaf is detected by the white spot and the bulge in the slit epidermis. It is laid in the upper part of the leaf, not far from the point. The

[1] 41. *Hispa ænescens.* Baly. (Chrysomelidæ.)

egg hatches to a small, flattened grub, with three pairs of legs, which lives inside the leaf between the upper and lower epidermis. The grub is white or yellow with black markings, very flattened, the first three segments broader than the abdomen. It feeds on the tissue inside the leaf, eating it away and producing a large yellow spot. The grub is found by searching for such yellow spots and the insect may be seen inside if a spotted leaf is held up to the light. The grub when full grown transforms to the pupa inside the leaf and emerges as the beetle. The whole life history is passed within the leaf until the mature beetle comes out to fly about. It feeds upon the leaf, eating away the epidermis and causing further destruction.

The insect principally attacks the young plants, feeding and laying eggs upon the tender green leaves of the seedling or of the newly transplanted rice. It is injurious to rice in the seed-bed and shortly after transplanting, the older rice being less attacked and not injured.

Wild grasses are the normal food-plants and the beetle flies from the waste lands or jungle to attack the early rice. In some parts of Bengal it is reported to come in enormous numbers, blackening the fields on which it settles and causing a wholesale destruction of the crop. Like the rice-bug it is dependent upon moist conditions and attacks rice that is submerged in preference to rice on higher land from which the water has been run off ; this is the only remedy applied by cultivators, who, when possible, let the water out in the hope that the insect will leave their fields.

The insect spends the winter as a beetle in waste lands and grass-lands. The season at which it appears depends upon the sowing of rice and the climate, but lies between April and November.

Preventive measures for this pest must be based upon local conditions : where the pest is known to come from a particular place, it may be possible to destroy it there, as, for instance, in the wild grasses in which it lives before the rice is sown, or the sowing and transplanting of rice may be varied to prevent the pest attacking it. In seed-beds the beetle can be destroyed, and if the seed-bed is watched when the beetle is likely to attack it, egg-laying can be prevented. When the beetles come in great number the ordinary bag is sufficient to sweep them up with, and the cultivator is quite capable of using his *dhoti* or other cloth for the purpose. Any concerted action designed to prevent egg-laying and worry the insect is what is required, and what is, in India, so difficult. When once egg-laying has been performed nothing can be done but to wait for the emerging beetles and destroy them. The use of arsenical insecticides is valuable as a poison for the beetle, but is ineffective against the egg or larva. There is probably little scope for the use of lead arseniate, since it will not stand rain and washes off. There is also

little scope for the use of smoke. Smoke is advisable as a means of checking the insects when they first come as it drives them out of the field; it has no further effect, kills nothing and is only a temporary device to frighten away the incoming beetles. No specific remedy can be recommended against this pest; the life history is so safeguarded that there is no obvious point of attack, and reliance must be placed upon preventive measures based solely on local conditions and aimed at destroying the insect in its breeding grounds, securing an earlier or later growth of rice to circumvent the beetle, or making the conditions unsuitable to the existence of the insect. The only available direct remedy is to destroy the beetles with bags, systematically working through the fields and sweeping them clean; this must be done promptly as soon as the beetles come, and must be thorough.

It has been found that certain softer-leaved varieties of rice are more attacked than rough hard-leaved varieties growing side by side, and in these cases the ryot has a remedy to hand. The higher priced soft variety is grown at a risk, when the rough variety might afford an almost certain full yield.

The Rice Bug.[1]

A slender green insect, found flying in the rice-fields, which sucks the sap of the developing ears and causes them to turn white. The insect has an aromatic odour, suggesting geraniums, and may be found in rice-fields when the grain forms. The characteristic symptom of the pest is the whitening ears, a whole field often turning colour in this way.

FIG. 132.
The Rice Bug. (*Magnified twice.*)

The insect is a typical bug, with no metamorphosis. The eggs are laid in the jungle, as also in the rice crop coming into ear. Each egg is oval, somewhat flattened, nearly black and very seed-like. They are laid separately, in clusters of four to ten, on the leaves.

[1] 103, *Leptocorisa varicornis.* F. (Coreidæ.)

They are quite easily seen, the eggs forming a conspicuous object on the green leaf. When ready, the egg opens, the delicate inner membrane and part of one end of the outer shell coming off and liberating the bug. The little bugs are most quaint insects, all legs and feelers, with a slender green body. The antennæ are banded in black, white and brown, the legs black, all extremely long in comparison with the tiny green body. The proboscis is very long, reaching beyond the insertion of the hind legs.

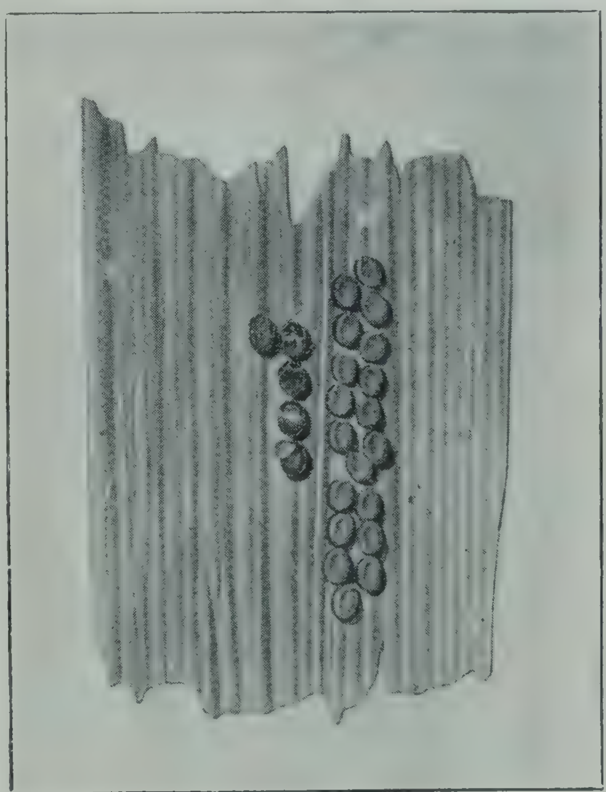

Fig. 133.
Eggs of the Rice Bug. (Magnified twice.)

At each moult the insect grows larger, the body remaining green. Wings are formed gradually. When full grown the insect is about two-thirds of an inch long, the wings folded over the abdomen, the body green with a tinge of straw colour, the antennæ parti-coloured. It flies actively and may be readily made to fly out of the field.

This bug feeds upon ripening seeds; it will attack rice, small millets, grasses and other plants as the seeds form and fill with milky juice. *Sama* (*Panicum frumentaceum*) is a favourite food, and the bug's normal food is the wild grasses in the jungle and waste lands. Though common in cultivation during the rains, it breeds only when a crop is ripening and food is plentiful. Then the eggs are laid on the leaves of the plant and the young find abundance of food.

Cultivators know the pest, which has many vernacular names, but do nothing to check it. It is prevalent in Burma, Assam, Bengal, the United Provinces and Madras, practically throughout the rice districts of India. In other parts of India it is to be found where the conditions are suitable; it extends to Ceylon, the Malay Peninsula, Malayan Archipelago and China. As the winged form is fairly active, it can be driven from the rice-fields with little effort. The unwinged young when disturbed simply fall to the ground or to the surface of the water, whence they climb upon the plants again. There is no easy means of checking it, but if sufficient trouble is taken and a large area treated, the insect can be destroyed. The simplest method is to draw a bag through the rice, simply running it over the plants. Two coolies can easily manage a bag

eight feet wide and three feet deep with the opening three feet high. Two bamboos keep open the sides of the mouth and the bag can be drawn tight and rapidly run over the rice, brushing through the upper half of the plant. The winged and unwinged are caught if the bag is at once twisted up at the close of each run and a very large area can be rapidly swept. The method is useless without co-operation, as a whole area must be swept clean or the bugs wander in again.

When the flying bugs first come in, the mere dragging of a rope through the crop drives them out again, and a little systematic worrying of this kind sends them back to the jungle. A remedy for this pest used in South India and Ceylon is to smear a paddy winnow with sticky fruit juice, fix it to a pole and wave it in the fields. The insects stick to the winnow if struck.

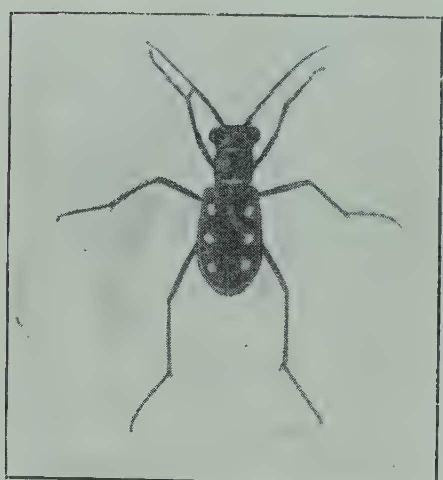

FIG. 134.
The Six-spotted Tiger Beetle that preys on the Rice-Bug.

A common hand net is more efficacious and just as easily made, and in actual practice the bag is better still. This method however appeals to cultivators and, if vigorously carried out, does destroy and drive away the pest.

In Bengal the rice-fields are found to contain numbers of very active blue beetles, marked with six white spots, which feed upon the rice bug. This is the Six-spotted Tiger Beetle,[1] a very valuable predaceous beetle which gathers in bug-infested rice-fields and keeps the bugs in check. Another check is a small parasite found in the eggs.

The Rice Stem Fly.[2]

The first symptom of this pest is the withering of the upper half of the plant, the main stalk bending over from a point some distance above the ground. The upper part withers and the main stem dies. If such a stalk is split up the middle, the maggot or pupa of the insect will be found.

Very little is known of the occurrence of this insect in India, as it has been reported very seldom. The maggots are found in the shoots of rice; they feed on the sap and produce a deformity and weakening of the stem. The stem eventually falls over at the weak point. The maggot transforms to the pupa inside the stem, the pupa being a

[1] 187. *Cicindela sexpunctata.* L. (Cicindelidæ.) | [2] 44. (Muscidæ acalyptratæ.)

small brown object like a flax seed. No specimens have yet been reared in India under observation and the details of the life history are not known.

The insect has been found or reported from a few scattered localities in the plains of India and is probably far more widely spread, generally escaping notice. It is attacked by a hymenopterous parasite.

Rice is not the only food-plant, *sama* being an alternative one.

No general methods of treatment are available against such a pest, and preventive measures based upon local conditions can alone be effective. Some good would be done if all affected plants were destroyed, but no remedial measures can check such an insect. It will be necessary to devise measures based on supplying the insect with a trap food-plant, such as sowing an early trap crop or destroying it in a particular plant or crop at one special period of the year. It may be possible to find immune varieties of rice, or to make such changes in the agricultural practice of affected districts as will baffle the pest, as, for instance, sowing earlier or later. It is not likely that any good will be done without careful study and some experiment, and what is found useful in one locality will not be likely to suit another.

Wood-Mason has recorded an insect [1] allied to the Hessian Fly which attacks rice in a somewhat similar manner. This is a distinct pest, of which practically nothing is yet known. Either insect is likely to be found in rice.

The Rice Grasshopper.[2]

Among the most familiar rice pests is a large grasshopper, green or dry grass colour, which lives in the rice-fields, becoming mature about

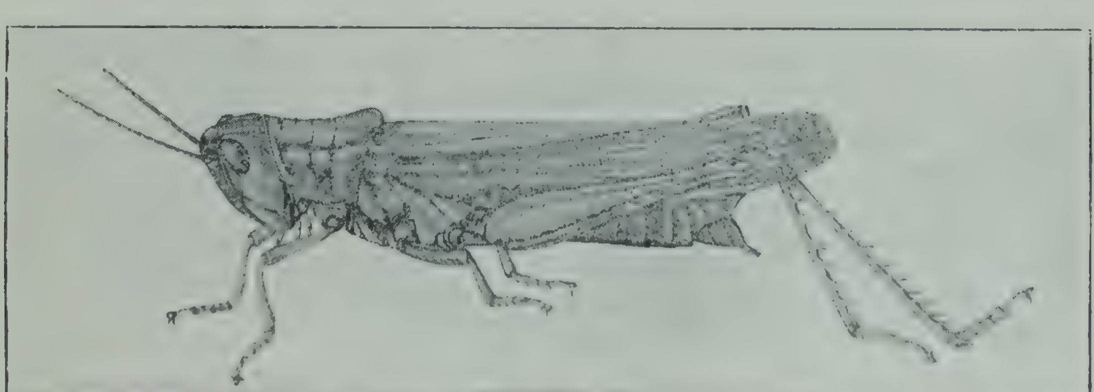

FIG. 135.
The Rice Grasshopper. Normal form.

[1] *Cecidomyia oryzæ.* W. M. (Cecidomyiidæ.)
[2] 47. *Hieroglyphus furcifer.* Serv. (Acridiidæ.)

August or September. It is easily recognised from the figure, the short wings, the uniform colour and the indented black marks on the thorax being distinctive.

The life history is passed in the rice-fields and occupies seventeen weeks. The eggs are found embedded in the soil, in the fields or embankments; each egg mass is a hard cylindrical body, about half an inch long with one end rounded, the other flat; the eggs inside are densely packed in a hard cement, and the outside crust consists of cement and earth. These eggs hatch after the first heavy rains and the small active insects emerge; they are at first dark coloured, with a green dorsal stripe, but later become green. The little insects are very active and feed on the growing rice. They undergo the usual five moults and become full grown in eight to ten weeks. The imago is found in two forms (figs. 135 and 138), one with the long wings, the other with short imperfect wings. As the insect never flies, wings are apparently useless. After mating the eggs are laid in the soil; this takes place in late September or early October, as a rule, but the dates vary according to the rains and the sowing and reaping of the rice crop. This grasshopper is found in grass-fields, in damp waste lands, in rice-lands and, more rarely, in sugarcane fields. It is also a pest of cane, and in irrigated cane-lands there may be an early brood of the pest, the eggs hatching when the land is irrigated in March or April. It is injurious principally by devouring the young rice crop or by eating the soft grains of rice in the ear. A useful method of dealing with this pest was worked out by Mr. S. Stockman and has been applied in the Central Provinces

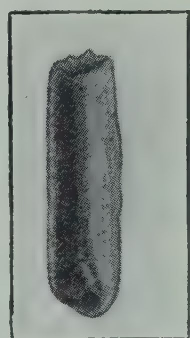

FIG. 136.
Egg Mass of Rice Grasshopper.

FIG. 137.
Egg Mass of Rice Grasshopper to show interior. (Magnified twice.)

FIG. 138.
The Rice Grasshopper, small winged form.

and Belgaum. It consists in dragging a net through the rice to sweep up the insects; the net is 36 feet by 7 feet, weighted at one side, with ropes on the bottom to drag it by, and a bamboo to hold up the top. Nine men drag it through the field, the lower edge below water sweeping up grasshoppers, caterpillars, and other insects. The method was successfully adopted in Belgaum and, where the cultivators work together, large areas of rice-lands can be effectually cleared of the pest.

Attempts to destroy the eggs during the cold weather have failed, owing to the difficulty of finding the egg masses, which are buried to a depth of two inches in the soil.

The Rice Grasshopper is common throughout the plains of Bengal, the Central Provinces, parts of the Bombay Presidency and Mysore.

Minor Pests.

A number of insects feed upon the rice-plant and it is uncertain which of these can rank as pests. Caterpillars are particularly common and a number have already been reared from rice but only rarely found to be injuriously numerous. An important local pest is the "*beddi*"[1] insect of Bhandara and Kanara, which is closely allied to the aquatic caterpillar[2] of Burma. The work of these is apparently identical; both eat the leaves and live in a case formed of a leaf-blade twisted over and

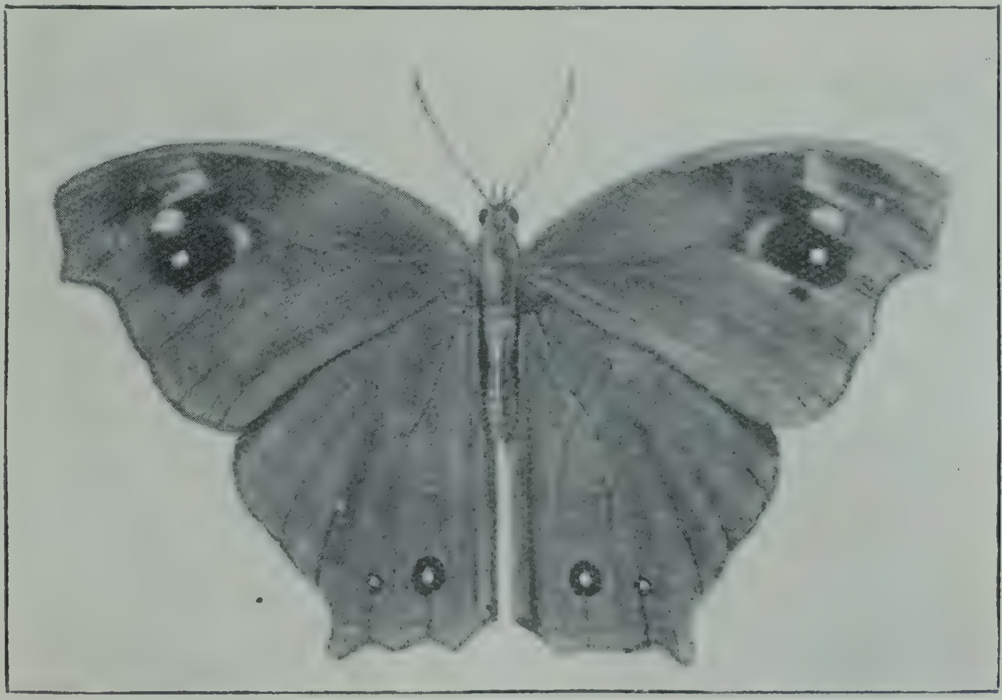

FIG. 139.
Butterfly of large Rice Caterpillar.

[1] 38. *Nymphula depunctalis.* Guen. (Pyralidæ.)
[2] *Nymphula fluctuosalis.* Zell. (Pyralidæ.)

made fast with silk. The caterpillar is a semi-aquatic one, provided with gills for obtaining air from water. If the water is let out of the fields, the insect is less destructive, and remains by day on the wet soil. It pupates in its leaf-case and the moths are found in large numbers in the affected fields.[1]

Another and larger caterpillar that folds over the leaf is the green caterpillar of a butterfly.[2] A large green caterpillar, distinguished by having two large processes on the head, is the caterpillar of the butterfly [3] reproduced (fig. 139). This caterpillar clings tightly to the leaf and is protected by its cryptic colouring. The larva of a small black and yellow moth [4] twists the leaf-blade into a shelter and feeds within. Other caterpillars live openly on the rice leaves, and it is not unusual to find that swarming caterpillars will destroy large areas of this crop (see page 187). One species [5] in particular appears in vast numbers on the plants, strips the leaves to the mid-rib and spreads rapidly from field to field. Against these pests, the bag (page 72) is often useful. Branches of trees placed in the fields encourage insectivorous birds which can perch there in the intervals of making a meal on these pests.

Blister beetles attack rice when in flower (page 206) and several cockchafers have the habit of destroying the soft grain before it is ripe (page 200).

The Wheat Stem Borer.[6]

It is not uncommon to find the stems of wheat withering prematurely, the plants becoming yellow and dying. Such plants contain borers, which will be found by splitting up the stems. The eggs from which these borers hatch are laid in clusters on the lower leaves near the stem; they are the usual small white rounded eggs, in compact clusters of twenty to thirty. The caterpillars bore into the stem of the wheat plant, feeding in the centre of the stem. The plant dies, withering up, and new shoots are formed at the base. The full grown caterpillar is about one inch long, smooth, with a brown head and a rather pinkish body; it is not the dull white of most borers, but tinged with pink and thus easily recognised. The chrysalis is found in the wheat stem. The moth is the colour of dry grass, similar in appearance to many other moths which live in grasses.

[1] Report of Ratiram Khamparia, Entomological Assistant, Central Provinces.
[2] 30. *Chapra mathias.* Fabr. (Hesperiidæ.)
[3] 236. *Melanitis ismene.* Cram. (Nymphalidæ.)
[4] 48. *Cnaphalocrocis medinalis.* Guen. (Pyralidæ.)
[5] 235. *Spodoptera mauritia.* Boisd. (Noctuidæ.)
[6] 91. *Nonagria uniformis.* Ddgn. (Noctuidæ.)

This species has been found during the cold weather in wheat and during the hot weather and rains in sorghum, rice and cane. It is a common cane pest in Behar, and an important wheat pest in Gujarat and Nagpur. There is a considerable amount of confusion as to the identity of the various wheat and rice borers reported in India in the past, but this species is probably the most important and will be found to be widespread.

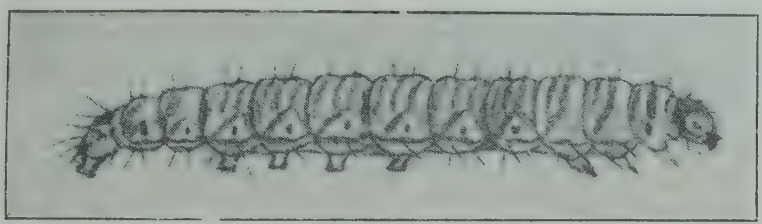

FIG. 140.
Wheat Stem Borer. (Magnified twice.)

There is no remedy for it beyond the few commonsense precautions which are suggested by the habits of the pest. When first found in a wheat crop, the crop should be periodically examined, and all withered plants at once destroyed. The pest is first found in the most advanced wheat in the districts where it multiplies, seriously injuring the later wheat. If the first brood is destroyed, no appreciable harm will result. It is unlikely that cultivators will ever find the eggs and destroy them, though this is quite feasible.

FIG. 141.
The Wheat Stem Borer Moth. (Slightly magnified.)

The increase of the pest is much assisted in sorghum-growing localities by the practice of leaving the sorghum stumps in the ground after harvest. With a few showers in February, the stumps grow new shoots in which the caterpillars of this pest are found after the wheat is reaped. This helps the insect through a very critical period. Where this insect attacks wheat on the experimental farm, spraying with lead arseniate must be resorted to if the full yield is required. It thrives on the plots of varieties of wheat, grown possibly with irrigation under abnormal conditions

FIG. 142.
The Wheat Stem Borer Moth. (Magnified twice.)

and possibly not even in a wheat-growing area; as in all cases of experimental cultivation special remedies should be adopted, when this pest is prevalent, by spraying with lead arseniate to poison the young insects as they hatch.

Minor Wheat Pests.

The most important minor pest of wheat is the *aphis* (page 237), a green *aphis* which infests the leaves and ears. It is a fairly general pest found in enormous abundance on ripening wheat. It is doubtful how much harm *aphis* does; at its worst it so weakens the plants and grain that only inferior wheat is produced. Beyond spraying, there is no remedy possible until further investigation has discovered the habits of this pest throughout the year. Spraying is practical only on experimental crops but is necessary there if the full results are to be obtained. Flea beetles (page 203) attack wheat, and germinating seed is destroyed by ground grasshoppers and surface weevils (page 220).

Termites are also a somewhat serious pest in some localities (page 228).

CHAPTER X.

PESTS OF CANE, MAIZE, AND SORGHUM.

THESE plants are so closely related that the same insects in some cases attack all of them. When this is the case, treatment of the pest in one crop is insufficient, so that it is necessary to consider carefully in which crop and at what time of the year the insect can be most easily destroyed. This is especially important with the Moth-borer, which is the most serious insect enemy of all three plants. Cane is also attacked by the White-borer, the Cane-fly, the Cane Mealy Wing; the Maize-fly attacks sorghum also.

Moth-borer in Sugarcane, Maize, and Sorghum.[1]

The most abundant and serious pest to sugarcane, maize and sorghum is the caterpillar known as the moth-borer. It is found in the caterpillar form, a slender caterpillar, not more than one inch in length, of a dirty white colour, with dark spots and a black head. It is not possible from the caterpillar to be certain of the identity of the pest, as there are other caterpillars which closely resemble it in form and colour. The moth can be identified, but it also is similar to other moths with similar habits: it is advisable, if caterpillars such as that described below, are found destroying these crops, to assume the insect to be the borer, until caterpillars or moths have been sent to an entomologist for accurate identification. Specimens are required from all parts of India to ascertain exactly where the borers occur and whether one or more species are thus found.

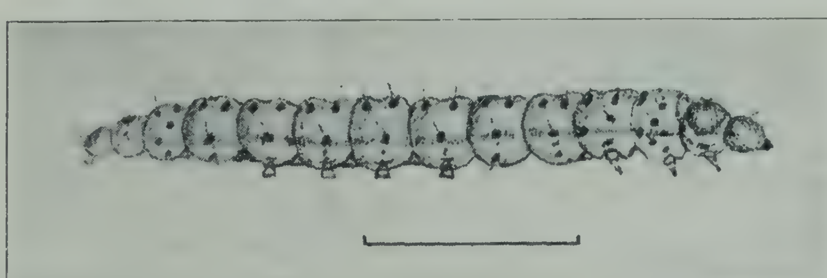

FIG. 143.
Moth-borer. (*Magnified three times.*)

Life History.—The female moth flies about the field after dusk and lays eggs on the leaves of the plants. The eggs are very flat, oval in outline, about one twenty-fifth of an inch across. They are laid in a cluster, one partly overlapping another, the number in the cluster varying

[1] 1. *Chilo simplex.* Butl. (Pyralidæ.)

from three or four to twenty or more. The whole cluster forms a small patch on the leaf, usually about a third of an inch in length and about one-twelfth of an inch across. When first laid, the eggs are creamy white, after which they turn yellow and then orange before hatching. In about one week the caterpillar comes out and leaves the empty white egg-shell. It commences its life as a tiny active creature, about one-tenth of an inch long, orange in colour, with many short dark spines and a black head. It feeds upon the leaves of the plant while it is young, and after a week or so enters the shoots or the stem. If possible it spends the rest of its caterpillar life inside the plant. The caterpillar grows larger, becoming a dirty white colour; the head is black; there are many little dark spots on the body, each of which bears a small dark hair. The usual three pairs of legs and five pairs of sucker-feet may be seen with which the caterpillar walks actively if disturbed. Life in this form lasts for about four weeks, except in the cold weather when it may last some months. When the caterpillar has become full grown and is a little more than one inch long, it makes a hole to the outside of the plant, spins a lining of thread inside the burrow near this opening and rests for two days. The skin is then thrown off and it turns into a chrysalis; this is three-quarters of an inch or less in length, brown, with no legs or mouth. The chrysalis lies in the burrow, unable to move except by wriggling, remaining thus for six to seven days. Then the skin splits open, and the moth comes out.

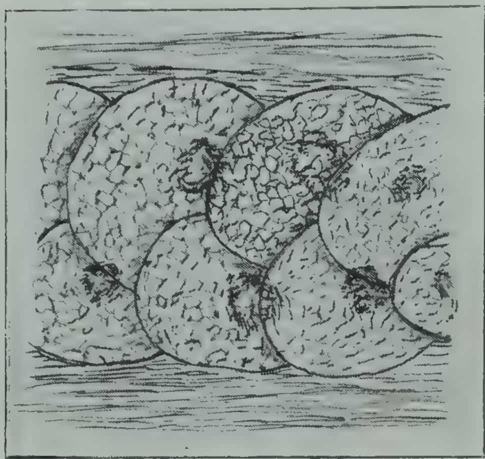

FIG. 144.
Moth-borer Eggs.
(Magnified twenty times.)

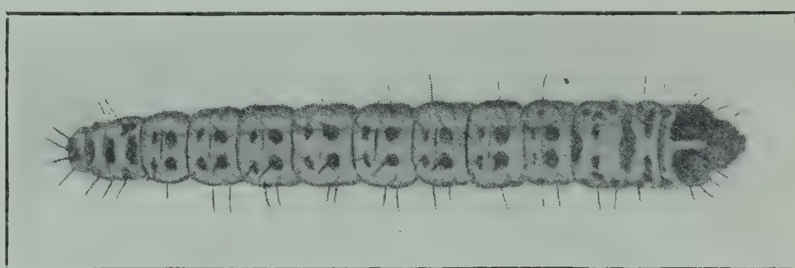

FIG. 145.
Moth-borer. (Magnified three times.)

FIG. 146.
Moth-borer Pupa.
(Magnified.)

This moth is of a grey brown colour, with long legs, with two pairs of wings and has two projecting palps in front of the head which look like a beak. The upper wings have dark markings, which vary very

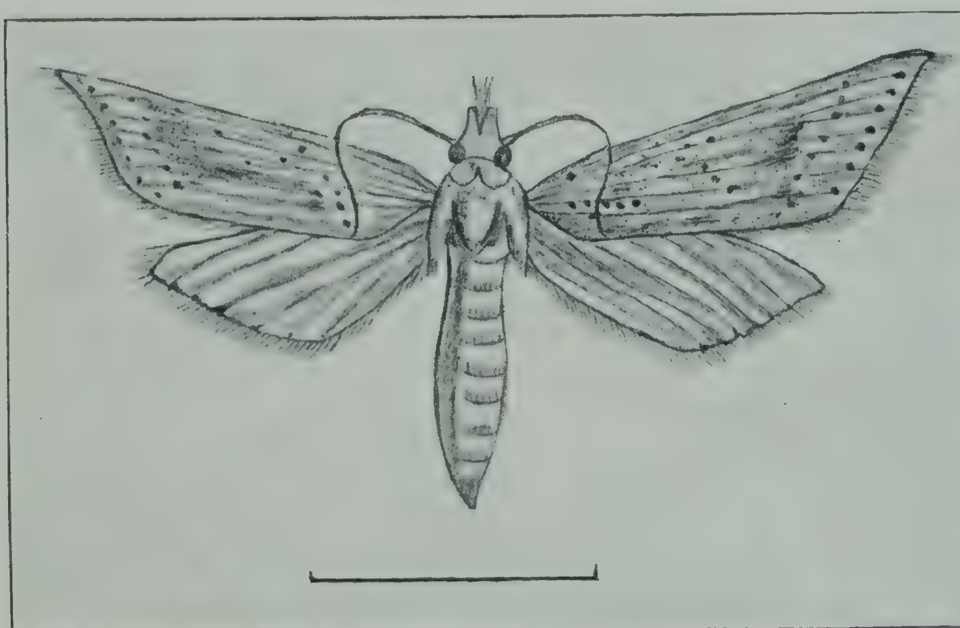

FIG. 147.
Moth. (Magnified.)

much in different specimens; the lower wings are white or slightly grey: when resting, the wings are carried close to the body, the lower ones not visible. When the wings are spread, the insect measures from one to one and a quarter inches across; the male is smaller than the female. It is impossible to describe the moth so exactly that it can be recognised as distinct from all other moths, but one point to look for are the palpi in front of the head which look like a beak; if these are not seen, the moth is probably not that of *Chilo simplex*, but one of the many other moths found on cane, maize, or sorghum.

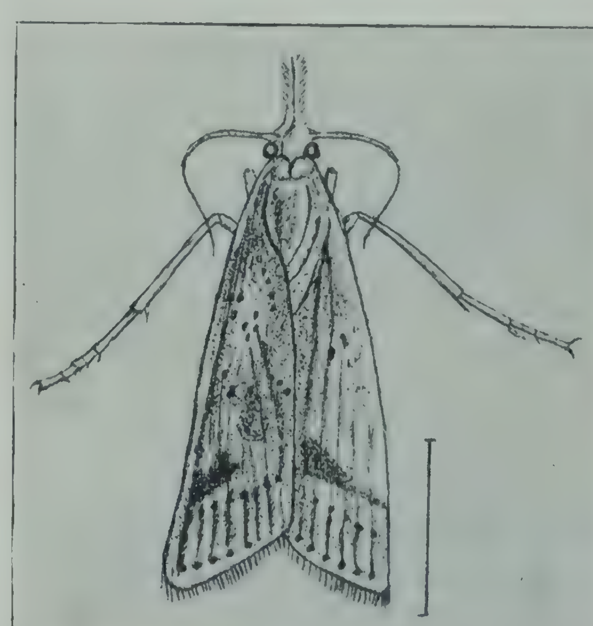

FIG. 148.
Moth in repose. (Magnified.)

These moths mate and the male dies, the female living a day or two longer in order to lay eggs. In ordinary circumstances, when there is plenty of food and the weather is warm, the whole life history

takes about six weeks, one week for the eggs, four weeks for the caterpillar, one week for the chrysalis, and a couple of days for the moth to lay eggs.

In November the caterpillar often ceases feeding, and rests; it does not change to the chrysalis, but simply lies in its burrow hibernating. It may remain in this state until the end of May, when it turns into a chrysalis and comes out as a moth in June. It may also come out and rest as a moth before this time; if there is irrigated cane or maize growing during the cold weather or dry weather, the moth may emerge as it does in the warm weather and never hibernate. This depends upon local circumstances, though the rule is that the caterpillar hibernates during the cold and dry weather, especially if it is in sorghum.

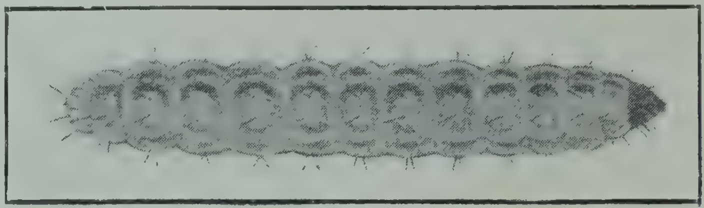

FIG. 149.
Moth-borer Caterpillar, in hibernating condition.
(Magnified three times.)

The caterpillar is often very destructive to young cane. The withered leaves show that the caterpillar has killed the shoot ('deadheart'). During the first five months many young cane shoots are killed in this way, the plants thus becoming weak and sickly. When the cane becomes larger, the caterpillar attacks the stem, boring into the growing canes. If it can find other food, such as maize or sorghum, it will often leave the cane, but if only cane is grown it may continue to attack and damage the cane. In sorghum, the caterpillar attacks the young shoots just as it does in cane; it also bores in the stems, being usually very abundant as the sorghum ripens. Where there are many caterpillars and each stem contains several, the crops may be seriously damaged. After the grain is harvested, the caterpillar remains in the dry stems and especially in the stumps, which are left in the field.

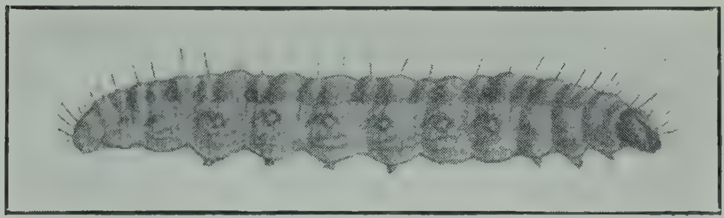

FIG. 150.
Moth-borer Caterpillar, in hibernating condition.
(Magnified three times.)

In maize the caterpillar lives in all parts of the plant, except the roots. It bores in the stems, feeds upon the tassel and is particularly fond of the cob. Many young caterpillars are often found in the ripening maize, eating the grain so that the harm is very apparent.

Remedies.—There are several things which may be done to check the increase of the moth-borer, but they will only be fully effective if they are all done, so that the pest is checked all the year round. No remedy will entirely kill out the insect, and if it is checked only at one season it will increase again during the rest of the year. In every place where the moth-borer is found, it should be attacked in cane, maize and sorghum, if all these are grown.

(1) Cut out all the young shoots of cane that are seen to wither. When the moth-borer attacks the shoots, the centre leaves wither and dry up; if these shoots are cut out with a knife, low down just below the soil, they can be taken away with the caterpillar or chrysalis inside.

This does no harm to the cane as the shoots would not live in any case and other young shoots will grow again just as well. These dead shoots should then be piled in a heap and burnt. They must not be left on the ground as the caterpillar will come out as a moth in due time and lay eggs in the field again. The object of cutting out the cane is to check the borer at the beginning.

(2) Sow maize or sorghum among the canes when the cane is planted. This will come up quickly and the moths may lay eggs in the maize or sorghum and the caterpillars will not attack the cane. The plants of maize or sorghum may then be removed with the borers in them, say in six weeks or two months after sowing. These plants must be removed from the field and if they have many insects must be destroyed. In any case the insects must not be allowed to come out as moths and breed.

(3) Cut out all young sorghum or maize shoots that are attacked and burn them. This is just the same as the first remedy and has the same effect. It can only be done in the young plants because it is only then that the shoots which are attacked can be seen by the withered leaves. When the plants get bigger, the borer cannot be cut out, because that would kill the whole plant.

(4) Destroy the stubble of the sorghum or maize plants after the crop is reaped. During the winter the caterpillars live in the stumps of the sorghum left standing in the field. From these caterpillars come the brood that attacks the crops after the winter. Great numbers can be destroyed in the stubble so that this is the most important remedy; the moth-borer will probably be more thoroughly checked by this practice than by any other remedy.

Enemies.—As the caterpillar lives inside the plant few insects can attack it, so that many enemies that feed upon most caterpillars are powerless. Three insects are known which lay eggs in the body of the caterpillars (figs. 151, 322); these eggs hatch quickly to maggots which live

in the caterpillar and gradually devour it. The caterpillar dies, the maggots come out and themselves turn to flies which lay eggs in other caterpillars. Few of these insects are found as the caterpillar is seldom exposed to their attacks.

A more important enemy is a very tiny fly which lays its egg in the eggs of the moth; the fly's egg hatches first and the maggot eats up the eggs of the moth. Such eggs are black in colour, not white or yellow, and very many such eggs are found in the fields of young canes. This tiny fly is the most important check upon the moth-borer and prevents the destruction of many cane-fields every year. Another enemy, which is very seldom found, only attacks the borer when it is feeding upon some exposed part of the plant, such as the tassel of maize. This is a very active small black grub, which runs about feeding upon the caterpillars. It kills the caterpillars by sucking out their blood.

FIG. 151.
Fly whose Maggot lives in the Moth-borer Caterpillar.
(Magnified twice.)

The moth-borer is found in many parts of India, but it is not certain that it occurs all over the continent. It is common in many places in the Bombay Presidency, Baroda, the Central Provinces, Bengal, the Punjab and the United Provinces. It will probably be found all over these Provinces and is likely to be the borer of cholam (sorghum) in Madras.

White Borer of Cane.[1]

Whilst the moth-borer is the common pest of cane, other boring caterpillars also attack it, some in the roots, others in the stalk. Of these the White Borer is the most prominent, found principally at the apex of cane boring through the growing joint and down the upper joint.

The moth lays eggs on the leaves of the cane, several eggs together in a cluster; the eggs are cigar-shaped, fixed to the leaf, and the cluster is covered with buff coloured hair taken from the tip of the moth's abdomen. When the moth deposits eggs covered with a gummy secretion, the hairs from the end of the body are plastered over the eggs.

[1] 121. *Scirpophaga auriflua*, Zell. (Pyralidæ.)

The egg cluster thus has a very characteristic appearance and can be readily found.

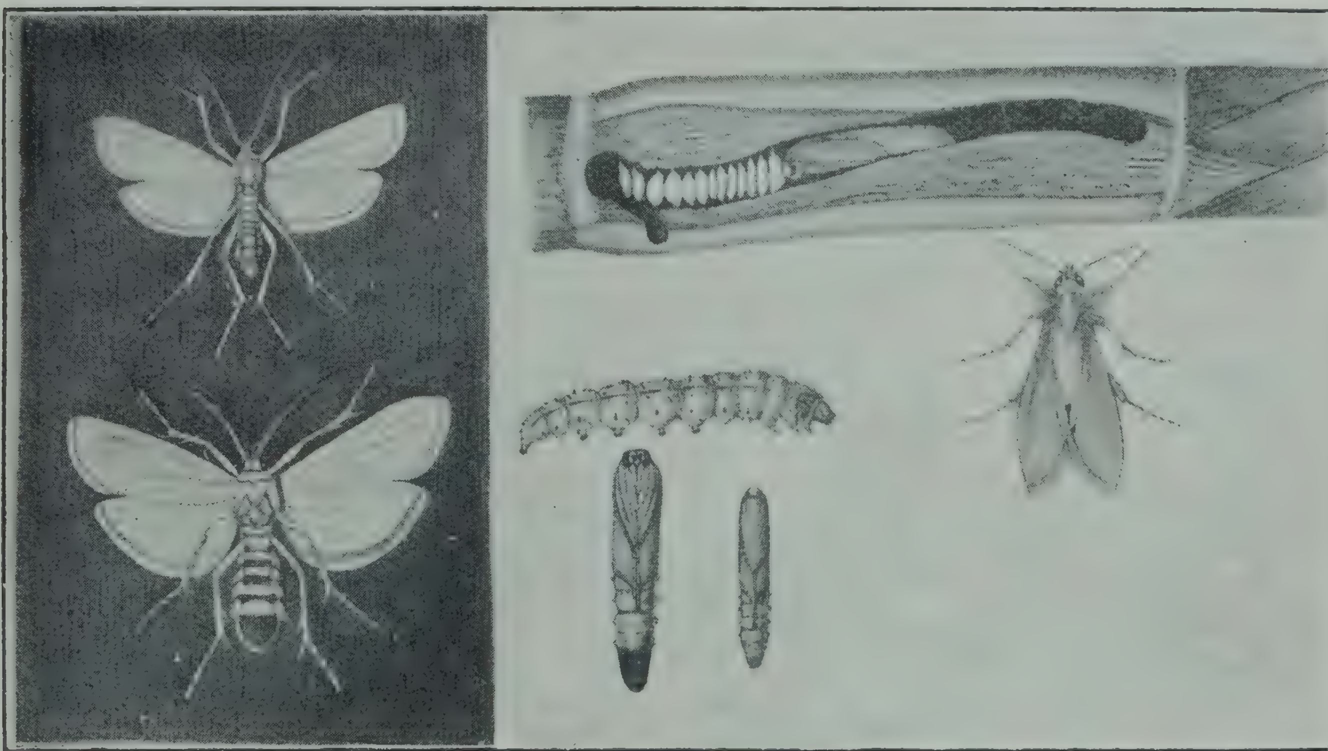

FIG. 152.
White Borer. Larva, Male and Female Pupa. Pupa in the cane, Moth, male above.

The larvæ that hatch are small spiny insects not unlike the moth-borer. They behave in much the same way, eating down into the rolled-up leaves of the cane shoot. They pierce the rolled-up leaves, which have a characteristic appearance when they open, the leaves being spotted with small holes. Eventually they bore into the growing point and straight down the solid part of the shoot.

In old canes the larva eats down the centre of the young rolled-up leaves above the growing point till it reaches the latter. The growing point is destroyed and the larva continues eating through the soft tissue, travelling downwards. When it becomes fully fed, it bores to the outside, reaching first the rind of the cane, then perforating the sheathing leaves. The leaf on the outside is not eaten away but a neat round disc is cut and left blocking the tunnel. The tunnel is then webbed with silk, and if there is a space between the rind of the cane and the outer leaf, this is bridged by a silken tube.

The pupa retires into the tunnel and prepares cross partitions as it goes, webbing the tunnel across with partitions. It then settles down, the skin is cast and pushed behind it, and the pupa lies head downwards in the tunnel.

The caterpillar bores through several internodes of the cane before turning outwards; as a rule there are at least three internodes between the apex and point of emergence.

In old canes, the death of the growing point by this caterpillar leads to the development of the buds next to the apex and some distance down the cane. The result is a cane bearing large shoots on the upper half, forming a bunchy top of long green shoots. Such canes are very conspicuous; the yield must be largely reduced, the cane instead of ripening normally, having to form shoots at the expense of its sugar contents. The upper half of the cane is also more fit for feeding cattle than for grinding. In young canes, the effect of the attack is to produce a "deadheart," a single dead shoot which grows no more.

Before the cold weather becomes severe, the larvæ that are full fed turn to chrysalides and remain thus throughout the winter. At Pusa, the first moth was caught in the fields in 1905 on March 9th, probably an abnormally late date. Many chrysalides could be found at that date, though they hatched out soon after. Probably the end of hibernation is a fairly distinct period, most moths hatching out about the same time. The commencement of hibernation cannot be fixed so clearly. Moths were common up to the end of October and in early November. After that none were caught and probably the last had emerged in November. All pupæ would then probably hibernate by the end of November, full fed larvæ would turn to chrysalides and smaller larvæ would feed till the cold numbed them, or till they could in turn become chrysalides.

The wings, legs, body, head, etc., of the moth are clothed in white scales, the only colour visible being at the end of the abdomen. In the female the abdomen terminates in a dense tuft of brown hair, the outer layer of which is red in the variety *intacta*. The amount of this hair is extraordinary, and as stated above is used for covering the eggs. The females are larger than the males and may be known by this tuft of hair. Both sexes can be easily found in the field, sitting on leaves of cane or other plants during the day-time, flying actively when the sun goes down.

As a rule mating takes place on the first night and egg-laying may occur on the second but may be delayed. Moths do not all emerge with the eggs fully developed; dissection of reared moths shows that in some the eggs are not so fully developed as in the majority and such moths probably live a day or two longer.

The number of eggs actually laid by moths cannot be accurately ascertained; even under the best conditions in captivity moths do not

behave normally; they may lay unfertilised eggs, they may lay no eggs, or few, or the full number contained in the ovary may be deposited irregularly. In natural conditions the eggs are laid a few at a time scattered over some area, each egg cluster being carefully finished off. In captivity this is not possible. Dissection of mature females shows that there are about one hundred eggs in the ovaries which appear to be uniform in size and fit for deposition; immature females will contain from sixty to seventy large eggs and others in various stages of development; probably one hundred is approximately the number of perfect developed eggs, and in normal circumstances the majority of these are probably laid.

The males die after coupling, the females after egg laying; the moths that can be caught in the fields are freshly emerged males or females that have not laid eggs.

The eggs are attacked by parasites, as are also the larvæ.

There are three methods of checking the pest :—

(1) The eggs can be collected on the young plants especially when the first moths come out at the first warm weather. These eggs should not be destroyed but be put in a tray or dish standing in a larger dish of water or into a tray with a gutter of water round the rim. The parasites hatch out and fly away, the caterpillars that hatch being unable to cross the water and dying. In this way the parasite is not destroyed, but continues to do its good work in the canes.

(2) The young shoots can be cut out when they are seen to wither, and the insect destroyed with the shoot. This is exactly similar to the remedy for moth-borer.

(3) The bunchy tops of the canes which are attacked can be cut out and used as fodder. The last is probably necessary only in bad attacks.

The pest has been found commonly in Behar and in parts of the United Provinces. It is also known in Java. The moth has a wider distribution in India and will probably be found in sugarcane throughout the plains.

The Sugarcane Fly.[1]

A dull straw-coloured insect, about half an inch in length, with a conspicuous upturned proboscis, which is found abundantly in the canes; it leaps and flies with great agility; the female is conspicuous by a mass of white material at the end of the body. This fly is not difficult to

[1] 147. *Dictyophara pallida.* Don. (Fulgoridæ.)

recognise, being found in great numbers in fields of old cane. The

FIG. 153.
The Cane-fly, showing Eggs, Nymphs and Imago. The nymphs are denuded of their mealy covering and processes.
(Magnified five times.)

female lays eggs on the lower surface of the cane leaf, near or on the mid rib; the eggs are oval, about one-twenty-fifth of an inch in length, pale green or yellow in colour. They are deposited in a loose irregular mass covered with white cottony material forming a conspicuous object on the leaf. From ten to thirty eggs are found in each mass. They hatch after a few days, and active young bugs emerge which are able to suck the juice of the plant. These insects have at the hind end a pair of long straight processes, covered in white mealy wax, which they can move apart or bring close together. They hop vigorously from leaf to leaf and rapidly grow larger. The wings appear as lobes on the back, and after five moults the perfect winged insect appears.

This insect is found only in cane, and is apparently widely spread over the Punjab, United Provinces and Behar, but has not been found in Western India. Its origin is obscure and though it becomes abundant in cane, it has not been found upon wild plants and, unless brought from cane fields, does not come out of the jungle and infest new cane lands. In old cane fields it is common, but the damage is appreciable only in the rare cases when it is very abundant.

The insect sucks out the juice of the leaves and cane, thus weakening the plant; the principal effect of its presence in large numbers is that the juice of such canes makes bad sugar.

The pest can be checked only by collecting the eggs regularly and systematically till the numbers of the insect are reduced. This is easier on young canes but usually necessary on maturing canes.

No other method is so simple and the use of insecticides for this pest is impossible.

Cane Mealy Wing.[1]

A disease of cane well known to cultivators, takes the form of small, oval, scale-like bodies attached firmly to the leaf; each is black in the centre, with a white fringe, about one-twentieth of an inch long, never moving about on the leaf. This is the immature form of the Cane Mealy Wing; it cannot be mistaken and is usually found in large numbers.

These scale-like bodies are the developing insects, corresponding to the half grown larvæ and pupæ of a moth. If the life history is traced from the beginning we find orange-coloured eggs, very small, laid singly on the leaf a number close together. The larvæ that hatch are small flattened insects, having tiny legs and antennæ, which walk a short distance on the leaf. As each finds a suitable place it inserts its fine beak into the leaf and fixes itself down. At the first moult it assumes the scale-like form and remains motionless; its food is obtained by suction from the leaf and the insect has no further need of legs or antennæ.

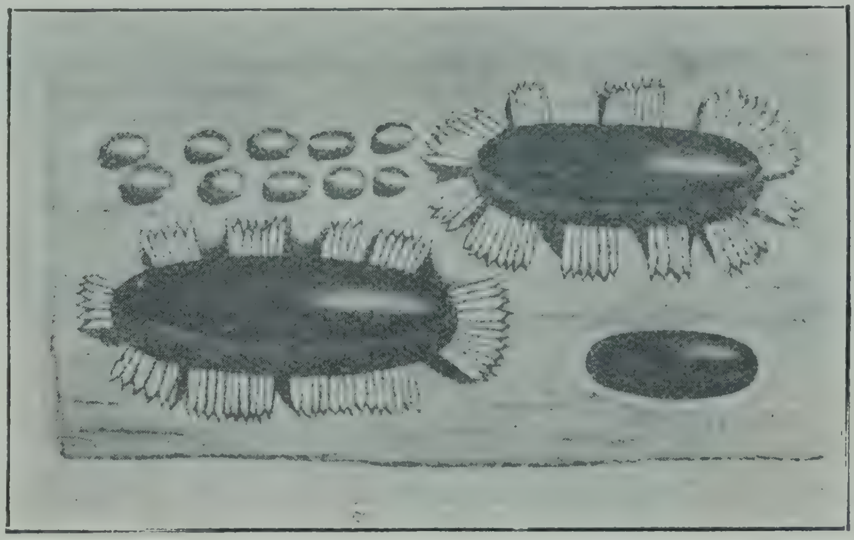

FIG. 154.
Eggs and Scales of the Cane Mealy Wing.
(Magnified twelve times.)

[1] Coc. 39. *Aleurodes barodensis.* Mask. (Aleurodidæ.)

Within this scale it completes its larval life, transforms to the pupa, and finally emerges as a tiny moth-like flying insect; there are now two pairs of wings, and both sexes are to be found. These mate, eggs are laid and the life history recommences.

This pest is common on cane in widely separated parts of India. Like other sucking insects, it is more numerous on weak cane, proving a serious pest if it once becomes abundant. The plant steadily loses vigour as the result of the constant drain of sap and unless it is growing freely becomes stunted and yellow.

Parasites attack the scales and it is not uncommon to find a large percentage destroyed. The pest cannot be treated once it becomes well established, and everything possible should be done to prevent infection of the young canes, either from the plant canes used or from neighbouring fields of uncut canes.

If the pest appears on young canes, the infested leaves should be removed. Poor canes that are not growing vigorously are sure to suffer from such pests; a vigorous healthy cane may become infested but suffers little from the insect. In most cases the insect is a sign of a poor cane, just as lice and ticks are of an unhealthy bullock, and the radical course is to grow a better cane or manure it more highly.

The cultivators of Gujarat regard this disease (*mosi*) as a very serious one and state that it decreases the yield from 100 maunds to 30 and renders the cane unfit for seed. They adopt no remedy but withhold irrigation in the belief that if the plant's growth is checked that of the pest will be checked also. This is probably erroneous. They also state that mist and damp kill the pest. The Behar cultivator has a similar belief in the destructiveness of the pest (*lahi*) but appears to adopt no remedy against it.

Minor Pests of Sugarcane.

The Rice Grasshopper (page 119) is reported as attacking sugarcane but is not generally a pest of this crop. The Rice Leptispa (page 201) is also reported as feeding on sugarcane leaves and the Sugarcane Hispa is actually found on cane but does no harm.

Termites or white-ants are serious enemies especially to young cane.

Three borers have been found by Mr. M. Mackenzie in Behar, and these are as yet little known. The larva of the Gold-fringed Moth[1] attacks cane much as the moth-borer does; the Green Borer[2] attacks the portion of the cane below the soil and a third borer[3] is found in the stalk.

[1] 122. *Chilo auricilia.* Ddgn. (Pyralidæ.) | [2] 146. *Anerastia ablutella.* Zell. (Pyralidæ.)
[3] 149. *Polyocha saccharella.* Ddgn. (Pyralidæ.)

Ground weevils of three species attack the young canes and are best checked by sowing maize or sorghum with the canes, to supply them with other food. Leaf-eating caterpillars eat the leaves of cane but are not of any importance. Three mealy bugs (page 245) are found on cane and may do a small amount of damage in the aggregate but are checked by sowing only clean seed canes.

The Maize Fly.[1]

A small dark-coloured insect, not unlike a large aphis, is found in the sheathing leaves of maize and sorghum. The insects are active, running crab like with a sideways motion and leaping away when disturbed.

Eggs are laid in the tissues of the plant, a cut being made in the leaf and the eggs deposited in the cut with a coating of white secretion.

The young are active, grey brown in colour, running in the heart of the plant. Large colonies of all ages are found in infested plants. They feed by extracting the juice from the tissues of the plant. Young sorghum plants are affected as well as maize. The insect is not a pest to field cultivation of maize in large areas, but to plots of maize grown where the crop is not a staple. It weakens exotic and unhealthy plants, and is one of the minor pests so common in experimental cultivation. It is allied to the cane-fly of the West Indies, an insect with similar habits which attacks sugarcane.

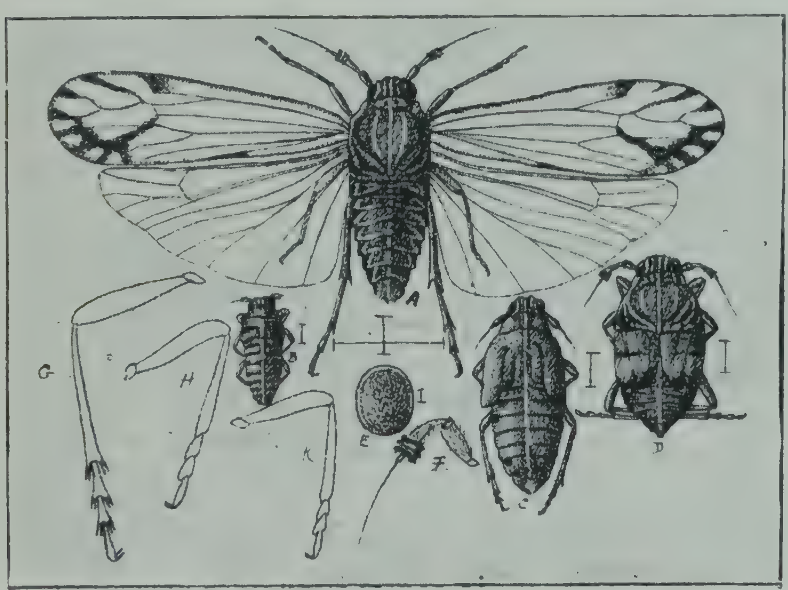

FIG. 155.
Maize Fly. a, *Imago.* b, c, d, *Young.* e, *Egg.* f, *Antenna.* g, h, k, *Legs.* (*All magnified.*)

Numbers of these insects are found in grass lands, being one of a large group of common sucking insects which are generally restricted to their wild food-plants. As a rule no remedy is needed beyond the simple one of dropping ashes or lime and kerosene into the heart of the plant to

[1] 4. *Delphax psylloides.* Leth. (Fulgoridæ.)

drive out the flies. In bad cases spraying is required, the ordinary contact poisons being sufficient to check the pest on a valuable plot of maize or sorghum.

Minor Pests of Maize.

Maize is the food-plant of a great number of insects which rarely do it serious injury; only where it is grown in small quantities and is not the staple crop do these pests become so numerous on each plant as to do much damage. Moth-borer is not uncommon in maize and may do much harm. The Hairy Caterpillar of Gujarat (page 193) will eat maize if it has no other food. Swarming caterpillars destroy maize as they do other crops but are not specially addicted to this crop (page 187). The maize leaf Caterpillar[1] does an inappreciable amount of harm in ordinary seasons by feeding on the leaves. Many other caterpillars attack maize, eating the young plants, feeding on the tassel or destroying the cob. None are specific pests; one particular pest of small irrigation crops in April and May[2] is fond of maize as also is the Gram Caterpillar (pages 144-45). The White Weevil (page 202) eats maize leaves and the two smaller Blister Beetles (page 205) have been reported as destroying the flowers of this plant.

Minor Pests of Sorghum.

This crop has few pests; the two smaller Blister Beetles (page 205) are quite serious pests, destroying the flowers and lessening the yield. The Wheat Stem-borer (page 122) also attacks it, and a leaf-eating caterpillar[3] is common in the young shoots but destructive only when in great numbers on a small area of the crop. This caterpillar does occasionally come in great numbers, feeding on the plant by night, lying hidden in the soil by day. When this is the case, ploughing or cultivation is advisable if it be possible. The caterpillars can be trapped under heaps of fodder laid on the soil, as they will gather there by day and can be readily destroyed. The moth-borer is the serious pest of sorghum though only rarely becoming destructive. The bugs that suck the heads of this plant in South India are stated to

FIG. 156.
Sorghum Leaf Caterpillar.

[1] 210. *Marasmia trapezalis.* Guen. (Pyralidæ.)
[2] 110. *Caradrina exigua.* Hubn. (Noctuidæ.)
[3] 29. *Cirphis unipuncta.* Haw. (Noctuidæ.)

be serious pests, much feared by cultivators. Other widespread pests in Madras are described by Mr. Barber.[1] Of these the mite which produces an appearance similar to rust is a widespread pest in some years. On the whole this crop appears to be fairly free from pests and, when grown in large areas, the pests are often so widely spread that little injury results.

[1] Bulletin No. 49. Diseases of Andropogon sorghum in Madras. (1904.)

CHAPTER XI.

PESTS OF LEGUMINOUS CROPS.

BESIDES the four pests described below, few insects are known to attack leguminous plants. This is largely due to the fact that these plants are mainly subsidiary crops, so that destructive insects have not the same opportunities for attack. The pests described probably have a greater range among the leguminous crops than is at present known; the pod caterpillar of tur is found on val (*Dolichos lab-lab*) and probably on other pulses.

FIG. 157.
Tur Pod Caterpillar on left, a bunch of spines as found on each segment on right.

Tur Pod Caterpillar.

As the *tur* or *arhar* (*Cajanus indicus*) crop ripens, the seeds are destroyed by small caterpillars. These are the larvæ of the Tur Plume Moth (fig. 160),[1] an insect first found in Nagpur and since recognised in several parts of India.

Life History.—The life history resembles that of other moths. Small round eggs are laid singly by the moth on the flower or small pods. These hatch in five days to small greenish caterpillars, which eat through the pod and feed upon the seeds within. The caterpillar does not enter the pod but makes a hole to the seed, and feeds from

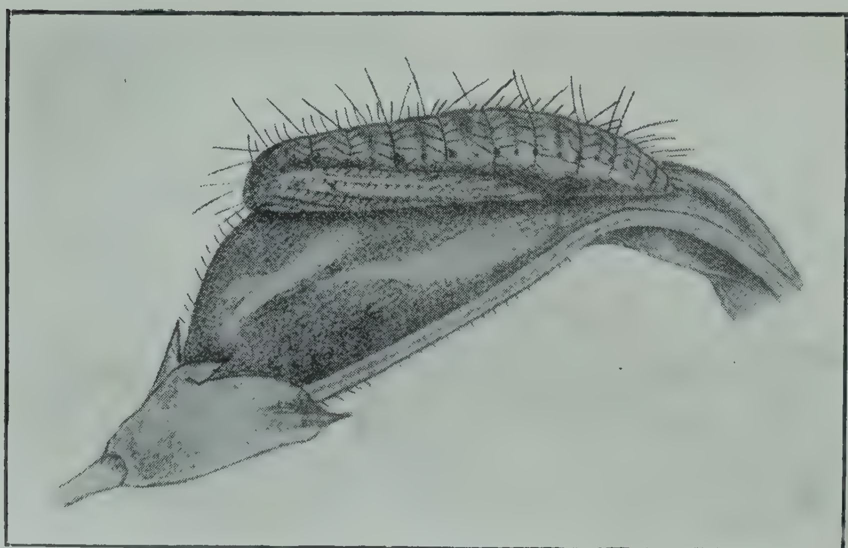

FIG. 158.
Pupa of Tur Plume Moth. (*Magnified six times.*)

[1] 72. *Exelasta parasita.* Meyr. (Pterophoridæ.)

outside. Having eaten one seed it makes a hole opposite another and attacks that. The larva is green or brown or a mixture of both. The colour is similar to that of the pod, that singular mixture of green and brown, and so is not easily seen. The body is dotted with dense tufts of spines and hairs, the former of peculiar form, either single or radiating from points in each segment (fig. 157).

After a larval life of 25 to 30 days, the chrysalis is found on the pod. It is coloured exactly like the pod and is clothed in fine hairs as is the larva. After seven days, the moth emerges, a singularly graceful moth, with long narrow wings. It may be found flying in the dusk and comes readily to lights (fig. 160).

Description.—The pest is a common one on tur or arhar (*Cajanus indicus*) and is found commonly in Bombay, Central Provinces and Behar. It has not been reported from many districts, but is an inconspicuous insect, and is probably common throughout the plains. Where this crop is grown extensively, the pest does no appreciable harm. Where small areas of tur are grown, it may be very

Fig. 159.
Pupa of Tur Plume Moth.
(*Magnified six times.*)

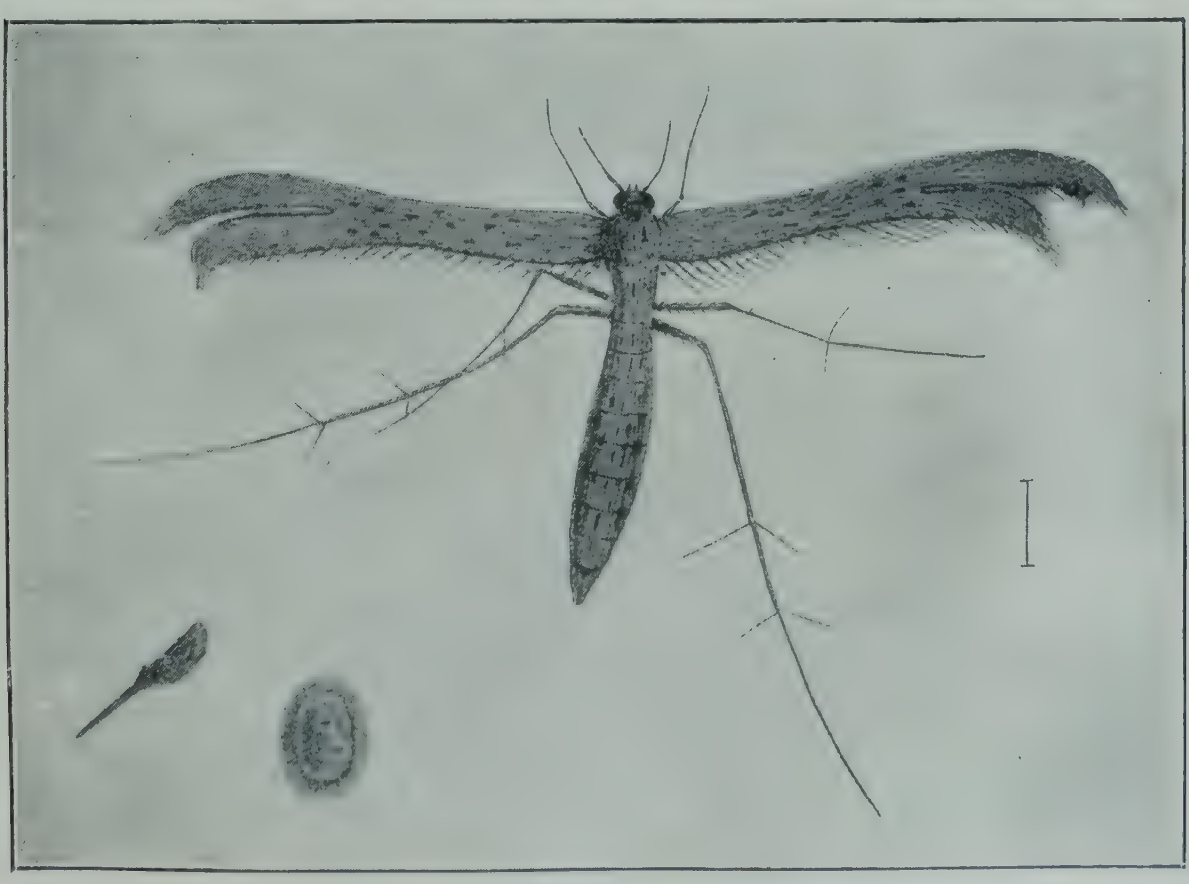

Fig. 160.
Tur Plume Moth. (*Magnified five times.*)

destructive, causing a loss of quite forty per cent. In addition to tur it has been found on val (*Dolichos lab-lab*) and probably attacks other pulses.

Remedies.—No case has been seen where remedies for it were required except in experimental plots. On such plots, spraying with strong contact poisons is a simple and radical cure. A sprayed plot gave an increased yield of fifty per cent. over a similar unsprayed plot. Serious attacks of this pest in large areas could be checked by hand-picking or other tedious methods, and where such attacks occur, preventive measures should be taken in the following seasons. The only really valuable preventive measure probably lies in not growing any leguminous crop, such as val, mung (*Phaseolus mungo*), etc., from the time the tur is picked till the next crop is ready. By this means the pest will be starved out and will not be abundant in the next season. This is a matter of local conditions, tur ripening so much sooner in some parts of India than in others. The pest has alternative food-plants in the small mass of leguminous crops grown in the hot weather and rains, chiefly vegetable crops which form pods at a time when the pest has not got its staple food.

Tur Pod Fly.[1]

A small white maggot, found feeding upon the seeds of tur; the injury is apparent only when the insect leaves the pod, there being at first no sign of the attack. A small hole in the pod is the only external sign of an infested pod. This pest was discovered in the Central Provinces [2] and has since been found in Behar. The fly lays an egg in the pod piercing the shell with her ovipositor and leaving a single egg behind. The maggot feeds upon the tur seed, first tunnelling under the skin, later devouring a large part of it. Only one seed is eaten and several maggots may inhabit the same pod. The maggot is a typical fly maggot, small, white, without legs or head, the mouth at the tapering end with small black hooks; in length it is one-eighth of an inch. When full grown it eats almost through to the outside, leaving only the thin outer skin of the seed intact. It transforms within to the brown seed-like pupa, and when the fly emerges, it pushes through the thin skin left by the larva and emerges directly into the air. Larvæ and pupæ are found in the same pod. The fly is a very small black insect, the wings large in comparison to the body. It is common in the tur fields, though not easy to find or to recognise from other small black flies. The female has an ovipositor, an organ resembling the sting of a wasp.

[1] 194. (Muscidæ acalyptratæ.)

[2] By Ratiram Khamparia, Entomological Assistant.

The life history appears to be a short one and broods probably succeed one another rapidly. The increase of the insect is checked by hymenopterous parasites.

No precautions are possible once the fly has laid eggs in the pods. Nothing can then be done to destroy the insect without destroying the pods also. It is unlikely that the insect causes serious harm in large areas of tur. Much has to be learnt of this insect before preventive measures can be devised.

Tur Leaf Caterpillar.[1]

This caterpillar feeds upon the small upper leaves of the tur plant, webbing them together into a small compact mass within which it lives. The webbed leaves are very conspicuous so that the pest is at once recognisable.

The moth lays eggs on the upper leaves, the eggs being laid singly, scattered over many plants. A small white caterpillar hatches, which feeds upon the leaf. It draws together the very small leaves at the tip of the shoot in the usual way characteristic of caterpillars; commencing with two leaves close together, it rapidly draws a thread between them, the thread being of soft gummy matter, exuded from the lower lip of the insect; first touching one leaf with the end of the lower lip it affixes the gummy matter, draws it rapidly across to the other leaf and so produces the first thread; it then returns, bringing a second thread to the first leaf and continues to move from one to another, producing small threads which rapidly dry and so contract; as the first threads dry they pull the two leaves together and the later threads are shorter; all the threads as they dry shorten and their united pull eventually brings the two leaves together; the caterpillar then commences on a new leaf, and draws that close to the two previously webbed ones, so continuing till it has prepared its habitation. Within this knot of leaves the caterpillar lives; it grows to a length of one quarter of an inch, smooth, with no markings, the head brown, a very small prothoracic shield and the body a yellow tending to orange. When full fed it pupates within the twisted leaves and a tiny dark-coloured moth emerges. This moth is never seen in the fields, being very small and coming out only at night or in the dusk.

This pest attacks the young tur plants in July, August and September. It produces a very characteristic form of injury, which is of little importance unless the top shoot is so drawn into the knot that it is killed. When only side leaves are drawn in, the leaves alone are killed, but where the top shoot is affected, it is bitten through and side shoots are

[1] 143. *Eucelis critica.* Meyr. (Tineidæ.)

thrown out producing a somewhat stunted bushy plant. In all the cases observed a very large percentage of the larvæ are killed by parasites, which puts a great check on the pest. The small white cocoons of the parasite are found in the twisted leaves of the caterpillar's dwelling and may be mistaken for some stage of the pest's life. The pupa of the pest is the usual small brown pupa lying naked in the leaves.

The pest has been found in several widely scattered districts in the plains. It is most abundant in plots of unmixed tur, less so where tur is sown with maize, til or other crops. These crops coming up more rapidly than the tur, serve to hide it to some extent, and though mixed crops are attacked, unmixed tur suffers more. Possibly this has some connection also with the habits of the parasite which may prefer the tur grown under shelter of another plant to tur grown in the open, and so destroy the insect more largely.

The very simple remedy of pulling off the affected leaves is sufficient to check it. These knots of leaves are readily seen and can be rapidly and easily collected by hand. The caterpillars collected should not be destroyed but placed in a box or some closed receptacle; the parasites will hatch out gradually, and if the box be cautiously opened in the day-time in bright light, they will fly out; the moths will not escape at the same time if the box is carefully opened. In this way, the valuable parasitic flies will not be destroyed, but will return to the fields to complete their useful work.

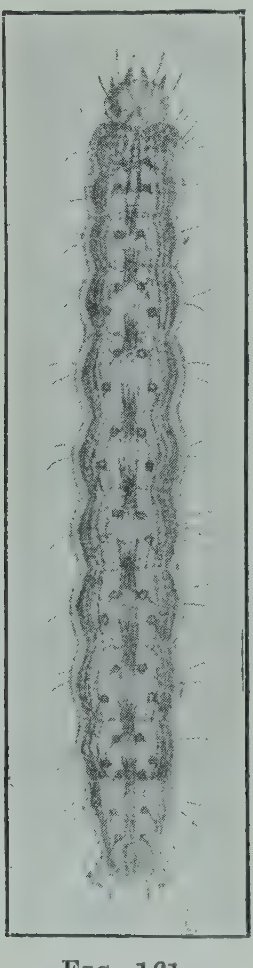

Fig. 161.
Gram Caterpillar.
(Twice magnified.)

The Gram Caterpillar.

The seeds of the gram plant are commonly eaten by a large green caterpillar, somewhat over one inch long when full grown, which sits on the outside of the pod. This is a cosmopolitan pest [1] which attacks an enormous variety of crops all over the world.

The life history is identical with that of similar caterpillars; the eggs are laid singly on the food-plants, small whitish eggs, round and beautifully sculptured; the caterpillars feed for a short time on the leaf or the outside of the gram pod and then bite through to the seeds; they feed from outside, attacking one seed after another, but not bodily entering the pod and remaining there. This period lasts about a fortnight as

[1] 90. *Chloridea obsoleta*, F. (Noctuidæ.) The American Boll-worm.

a rule, when the caterpillar descends to the ground, buries itself and transform to the chrysalis. The moth emerges in as short a time as six days in the hot weather, but may remain over one month or even up to three months in localities where the winter is cold. The shortest actual life

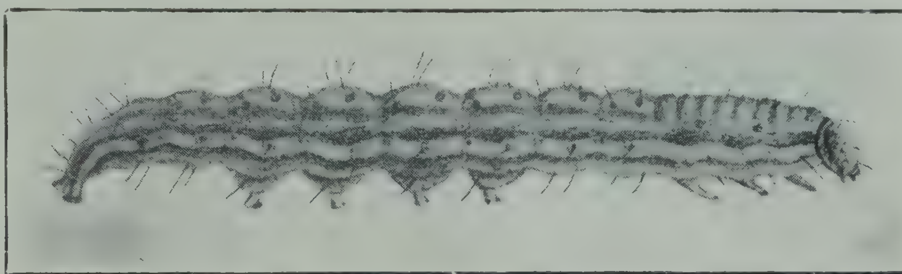

Fig. 162.
Gram Caterpillar. (Twice magnified.)

history is very little over three weeks when the temperature is high and food plentiful. This species attacks a great variety of plants but is chiefly known as a pest upon gram, which it attacks severely.

Where the winter is mild, the caterpillars are found throughout the season on gram, and there may be more than one brood in this crop. Where the winter is colder, the moths emerge from hibernation and attack the gram ; this occurs in Behar in late February or early March in normal years ; if many moths come out then and lay eggs on the gram, there may be a considerable loss. From this time till the following November there is a succession of broods on various plants.

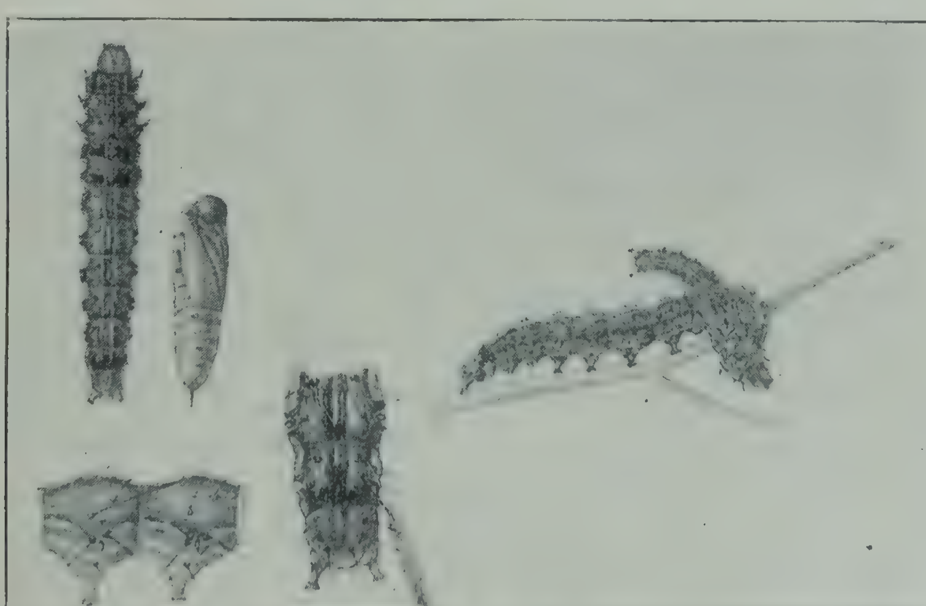

Fig. 163.
Gram Caterpillar and Pupa. On the right one caterpillar eating another.

Opium (*Papaver somniferum*) is much attacked, the caterpillars eating the capsules ; tobacco seed capsules are eaten, as also the pods of

tur (*Cajanus indicus*), the fruits of tomato and the seeds of bajra (*Pennisetum typhoideum*) and sunflower (*Helianthus* sp.).

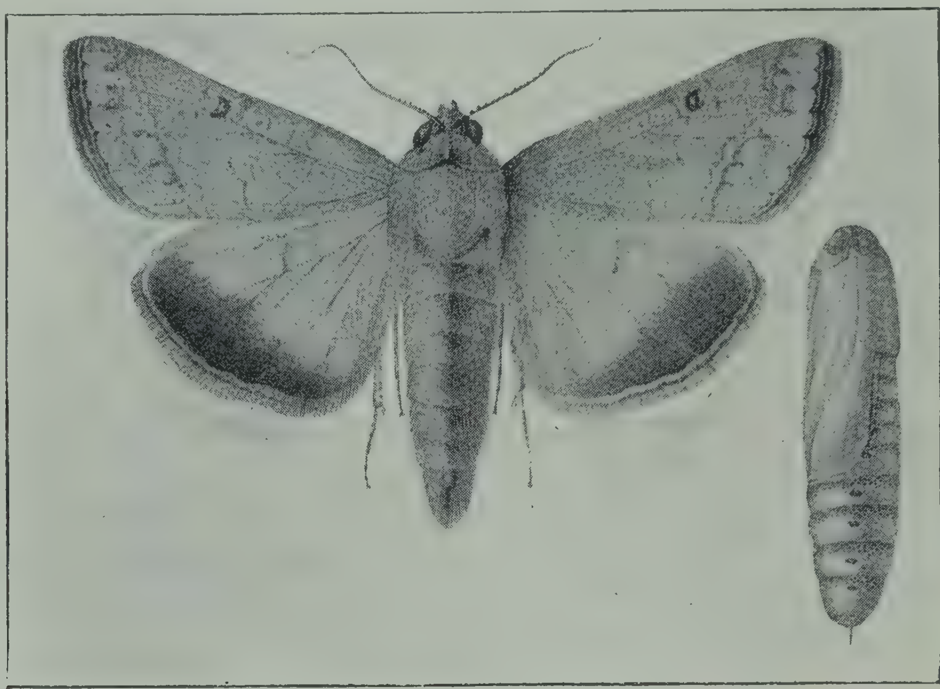

FIG. 164.
Pupa and Moth of Gram Caterpillar. (Magnified twice.)

The leaves of the indigenous indigo (*Indigofera sumatrana*), of lucerne (*Medicago sativa*), of maize and the wild *dhatura* are its food-plants at different seasons of the year; it is believed to be the caterpillar attacking the *ganja* plant (*Cannabis sativa*), and there are many records of rather doubtful food-plants, in Indian Museum Notes. The above is only a partial list of its food-plants, the moth having been actually reared from caterpillars found feeding on each of these plants.

With this great list of food plants, the moth presumably finds little difficulty in laying eggs and the pest can thus live at all seasons of the year. In America the insect attacks the bolls of cotton, a habit never recorded against it in India. Its attacks on gram, on opium and perhaps on *ganja* are important on the whole, though perhaps rare. The caterpillars are noticeable for their colour variations, and it is impossible to describe them. Green is the basis of the colouring with brown stripes; or brown almost obscures the greens or blends to form a variety of neutral tints. Another feature is their carnivorous habits; they devour one another readily when shut up together or when food is scarce, and the artist has attempted to depict this (fig. 163). They are also noteworthy for their feeding habits. As a rule they feed on pods or capsules, stretching in from outside to reach the seeds and never going inside

the pod; having eaten one seed they move down the pod and eat in opposite another. The species is known from every continent and has become extraordinarily omnivorous.

There is no trustworthy record of this species behaving as a surface caterpillar or 'cutworm,' though it is possible it may do so; nor does it often appear to come in large swarms and move from field to field. It may be characterised as a pod and fruit caterpillar becoming a typical leaf-eating caterpillar only when it must do so.

It is doubtful if any further treatment than hand-picking is ever possible or desirable except in cases of bad attack on small areas of experimental cultivation, where spraying may be necessary. The caterpillars are large and should certainly be hand-picked in early gram and opium in order to prevent the later brood from being very large.

Minor Pests of Groundnut.

Groundnut is on the whole fairly immune from insect pests but is injured by hairy caterpillars (pages 161-62). These caterpillars have a predilection for groundnut, and where they are abundant will destroy a field in a very short time. In districts where hairy caterpillars are found, the crop should be protected. Another common insect which likes the groundnut is the big cricket, whose habits are described elsewhere (page 224).

A small black caterpillar webs up the leaves and lives within the webbed shoot; this is not destructive but is likely to be thought a serious pest. White-ants greedily attack groundnut and may be a very serious pest. The

FIG. 165.
Moth of Groundnut Hairy Caterpillar. (Magnified twice.)

leaf-miner[1] of groundnut in South India and Ceylon is a pest which becomes of importance only when the climatic conditions are abnormal and favour it.

Pests of Sann Hemp.

The Sann hemp (*Crotalaria juncea*) is very commonly attacked by three species of hairy caterpillars which come in large numbers and eat the leaves. These caterpillars are much alike with slender bodies covered in short hairs, the usual colour being black or brown with yellow or white (fig. 168). The life history is much the same in the three species; the moth lays a mass of small white eggs in clusters on the lower side of the leaves; these hatch in three or four days to small dark caterpillars which feed voraciously on the leaves. They rapidly grow larger and in a fortnight are full grown, when they bury themselves in the soil with a light cocoon round them in order to pupate. The moth emerges after four to six days. The moths are characteristic; all are bright coloured and they can be seen in the fields clinging to plants or fluttering about in the daytime. The commonest species[2] is white, speckled with red and black (figs. 166-67); another[3] is a brilliant orange with black speckles; the third[4] has the fore-wings a dull red with black speckles edged with gold, the hind-wing red with black spots.

FIG. 166.
The Red Spotted Ermine Moth.
(Magnified two and a half times.)

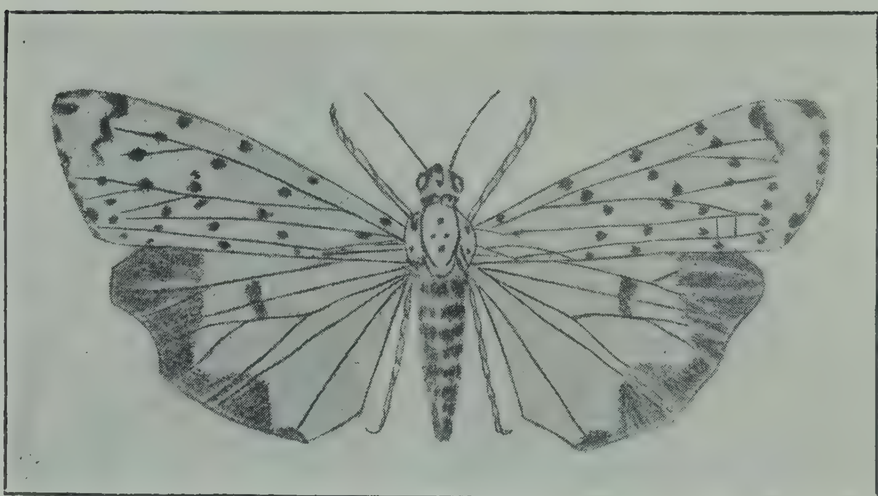

FIG. 167.
The Red Spotted Ermine Moth.
(Magnified two and a-half times.)

[1] 273. *Anacampsis nerteria.* Meyr. (Tineidæ.)
[2] 137. *Utetheisa pulchella.* L. (Hypsidæ.)
[3] 56. *Argina cribraria.* Cl. (Hypsidæ.)
[4] 55. *Argina syringa.* Cr. (Hypsidæ.)

The moths lay their eggs also on wild plants, breeding particularly upon leguminous plants. There are several broods in the year, the first in March or April, the second in June or July, when the bulk of the caterpillars are found on the sann plants.

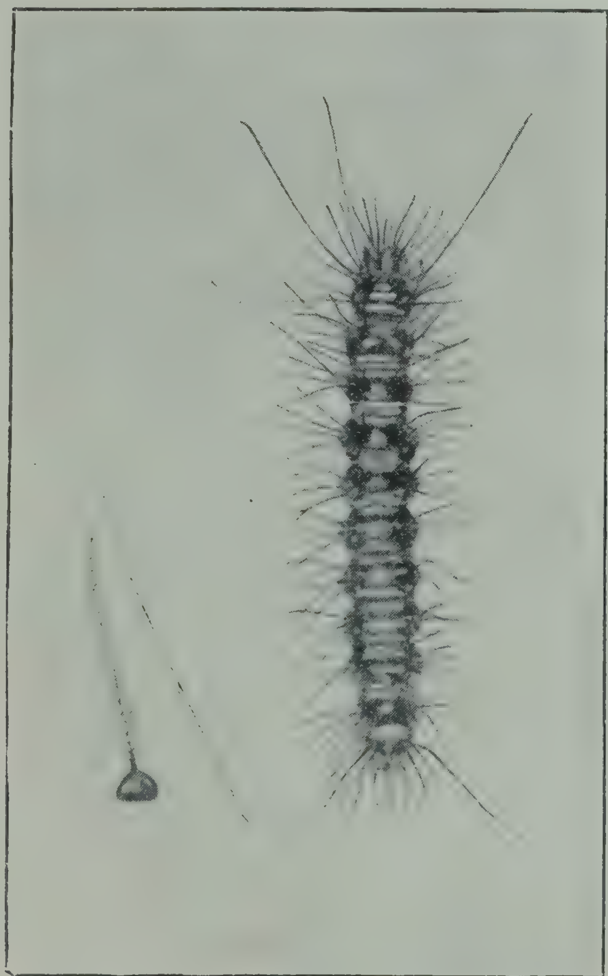

FIG. 168.
Hairy Caterpillar. (Magnified twice.)

The great safeguard against these pests lies in clean cultivation, thus affording them no food-plants at times when sann hemp is not available. It is also possible to collect the clusters of eggs and the newly hatched caterpillars if a sharp watch is kept when moths are seen in the field. Nothing can be done to a crop that is once badly affected except to spray lead arseniate.

Sann is also attacked by a small brown flea beetle, which eats holes in the leaves; the beetle does little harm but it is likely to be thought a serious pest.

Other Pests of Leguminous Crops.

Mung (*Phaseolus mungo*) is attacked by the caterpillars of the moth[1] figured, which eat into the base of the pods and destroy the seeds; the caterpillar remains within and eats seed after seed until it is full fed, when it pupates in the ground. This form of damage is very characteristic and the pest easily found. It is as yet doubtful how far this pest occurs generally, as it has not been commonly

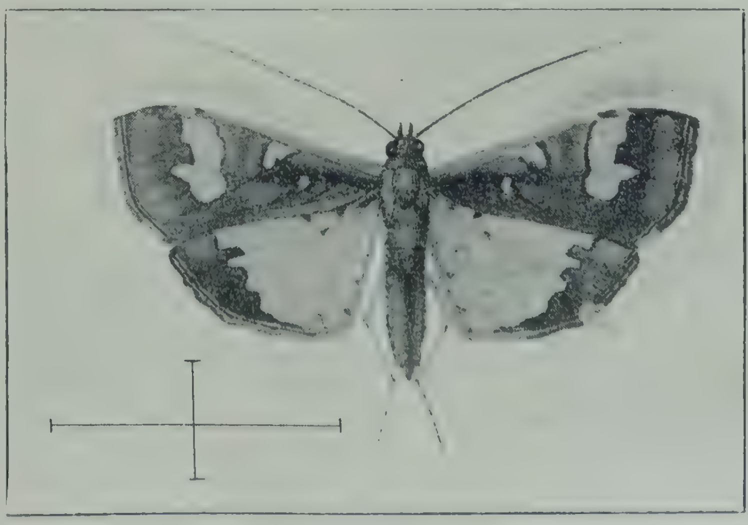

FIG. 169.
Mung Moth. (Magnified.)

[1] 231. *Maruca testulalis.* Gey. (Pyralidæ.)

reported; probably no remedies are required and no easy way of checking it is yet known.

Soybean (*Glycine soya*) suffers from surface grasshoppers when quite young, from leaf-eating caterpillars of several kinds as it grows larger. Except in places where the conditions are suitable, the crop is likely to suffer much from these pests.

Indigo is attacked by a variety of insects, none of which appear to be of very great importance. An aphis [1] and a small scale-like insect,[2] which gather in abundance on the shoots, are pests which weaken the plant and, should the latter not be healthy, will seriously damage it. The *bherwa* of Behar is a pest of indigo as of other crops grown where these insects thrive (page 227). Caterpillars of many kinds attack indigo as they do most luxuriant crops, and the indigo plant naturally suffers more as it is grown at a time when other vegetation is not available. It is worth noting that the Java-Natal variety of indigo suffers less than the other varieties of indigo generally grown in Behar. Little is known of these caterpillars and none appear to be specific pests of indigo.

[1] 83. *Aphis cardui.* Linn. (Aphidæ.) | [2] *Psylla isitis.* Buckt. (Psyllidæ.)

CHAPTER XII.

PESTS OF MISCELLANEOUS FIELD CROPS.

THE number of miscellaneous field crops in India is so large that the pests are probably numerous. However, not very much is at present known of the pests of minor crops, and a number of insects can be omitted because they come into well defined classes of pests not needing individual discussion. Pests of these crops are likely to be more local and far more varied than is at present believed. The few that are discussed here are general in the plains, so far as their crops extend. Very many new ones remain to be found and among them many very interesting insects peculiar to India.

Jute Pests.

The insect pests of the jute crop (*Corchorus olitorius* and *C. capsularis*) are as yet but little known. A small black weevil[1] breeds in the stems of the jute, the grub being found tunnelling near the axils of the leaves. The grub is a very small white insect, legless, with the usual biting mouth-parts; it makes small tunnels in the jute stem, causing the plants to become stunted and wither. In some cases one grub is found to almost every leaf; the tunnels extend about an inch up and down the plant, and about half-way across the stem. The perfect insect is a very small black weevil with long slender beak; it is found eating holes in the leaf of the jute plant. Nothing more is known of this pest, which was found on jute in Bengal by Purushottam G. Patel.

A pest of jute grown experimentally in Behar is a green semi-looping caterpillar; the first pair of prolegs is reduced in size, the body and head green; two lateral stripes of white run from head to tail and there are numerous black spots with white edges on each segment. This insect lives on the top of each plant, eating the leaves and eventually destroying the bud, so that the growth of the main shoot ceases. It has been found only on jute and is apparently a specific pest of this crop.[2]

Jute also suffers from hairy caterpillars (pages 161-62). Germinating jute is attacked by the ground grasshoppers (page 221), and before sowing it is advisable to clear grasshopper-infested land of them.

[1] 212. *Apion* sp. (Curculionidæ.)
[2] 229. *Cosmophila sabulifera*, Guen. (Noctuidæ.)

The Mustard Sawfly.[1]

Mustard, rape, cabbage and other cruciferous plants are eaten by the larva of one of the few plant-feeding *Hymenoptera* known in India. This larva is a black caterpillar-like insect; it may be distinguished from the true caterpillars by having eight pairs of sucker-feet instead of five; it is a small insect not more than half an inch long, of a dull black colour; the skin has the appearance and feel of velvet.

It is a pest to field cultivation of mustard, rape, etc., as also a more serious enemy to the cabbage and radish crops grown by market gardeners. The larva feeds in the morning and evening, descending to the ground by day. When full fed, it makes a slight covering of silk between two leaves and turns into the pupa, from which the perfect insect emerges in 10 to 12 days. The imago looks like a fly, with a rather short thick-set body marked in black and orange and with two pairs of dark wings. It is a very inconspicuous insect but may be caught in the fields.

The female lays her eggs singly in the tissue of the margin of the leaf, splitting the edge and depositing an egg inside. There are several broods in the year and the larva continues feeding in the cold weather upon the rabi crops. It is rarely destructive where a large area of cruciferous crop is grown: when it infests small plots or garden cultivation it may cause a large loss. Dusting lime, ashes or soot on the plants has a deterrent effect for market gardens: this is the simplest precaution. Lime or road dust mixed with kerosene is better than ashes. The same applies to field crops; only small areas are affected and in them a good dusting with any of these mixtures is sufficient to check the pest. The cultivator's practice of collecting the larvæ by hand in an earthen pot and carefully liberating them outside the field is of course a useless precaution; the larvæ simply go into the ground and crawl back into the field as soon as it is dark. This insect has been found in widely separated localities in India and is probably of general occurrence.

The Diamond Back Moth.[2]

In several parts of India crops of cabbage, mustard, radish and similar plants have been attacked by the little green caterpillars of this moth. The leaves have holes in them and present a withered appearance, being in some cases eaten almost completely. The pest is familiar to those who grow these crops, and the cultivators round Surat collect the caterpillars in water and throw them outside the fields. The pest is probably a common

[1] 54. *Athalia proxima.* Kl. (Tenthredinidæ.)
[2] 3. *Plutella maculipennis.* Curt. (Tineidæ.)

one, but as it attacks plants which are grown chiefly on small areas near towns, it does not rank as an important pest and has escaped notice.

Life History.—The moth lays small white eggs on the leaves of the plant on the under side. From these eggs come the caterpillars, slender green creatures, thick in the middle, which feed upon the tissue of the leaf,

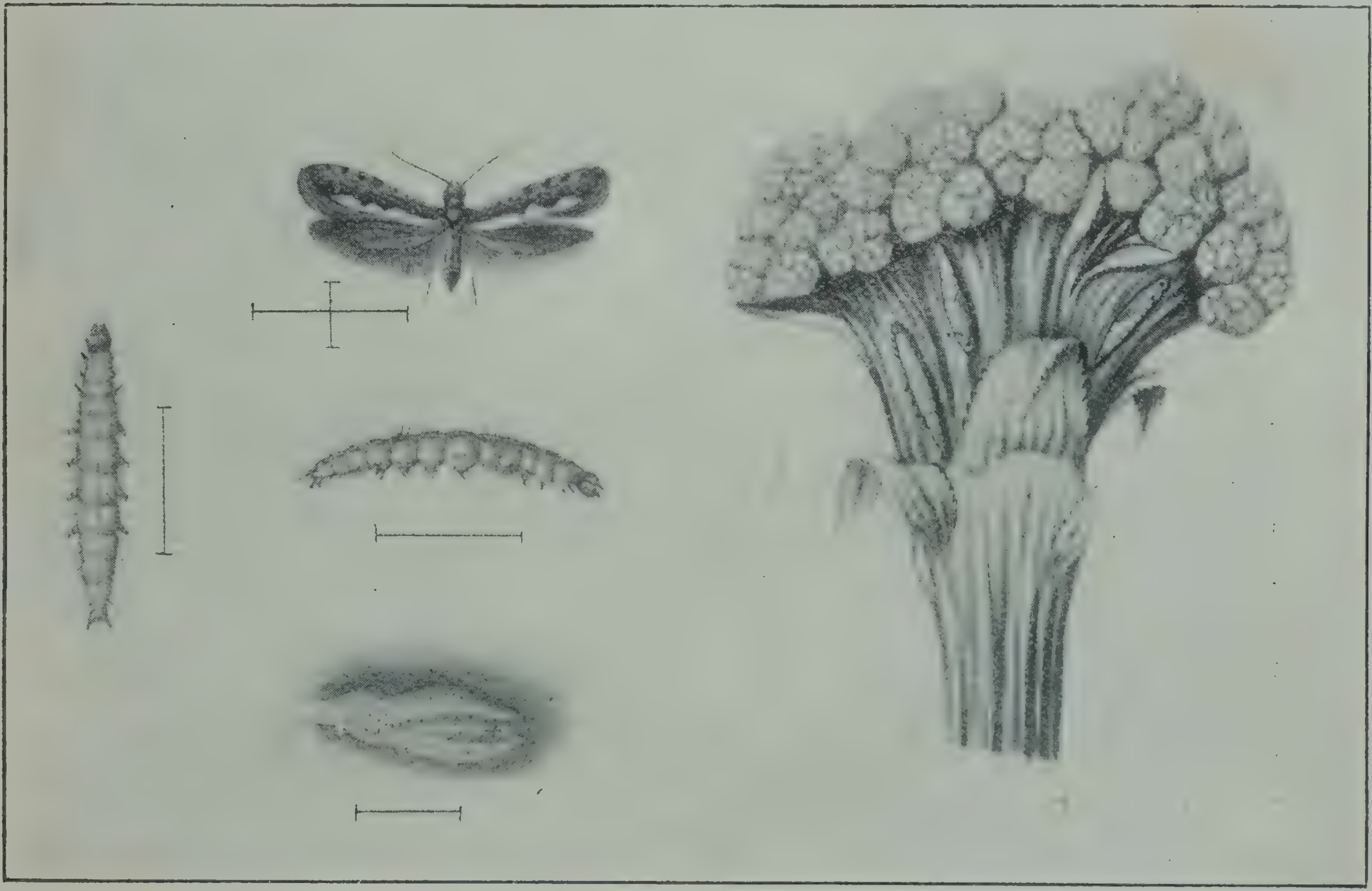

Fig. 170.
Diamond Back Moth. (*Magnified.*)

not biting it through but eating off the lower surface. These portions of the leaves wither and holes appear in a short time. The caterpillar is about half an inch in length when full grown, the head is small, the body almost devoid of hairs. There are the usual three pairs of legs and five pairs of sucker-feet. The caterpillar lives and feeds for about a fortnight and then constructs a very beautiful cocoon of white silk. The cocoon is very light, of a fine texture, and the green chrysalis is visible within. This is the resting stage, the chrysalis remaining motionless inside for about one week, becoming a little darker in colour. The moth then emerges. It is very small, nearly half an inch long when the wings are folded, with an expanse of two-thirds of an inch across the open wings. The prevailing colour of the wings and body is brownish grey ; the fore-wings have darker spots and a light line along the inner edge. When the fore-wings are

folded, the light marks on the wings come together forming the characteristic diamond marks along the upper surface, from which the moth takes its name. The moth may be seen in the fields flying from plant to plant or resting on the plants. There are several broods in the year, overlapping irregularly, so that insects of all ages are found at the same time. Probably there are at least eight and possibly twelve generations in a year, the insect being active through the cold weather and continuing its life history as at other times.

FIG. 171.
Diamond Back Moth.
(Natural size and magnified.)

Remedies.—The pest is a serious one to growers of cabbage, mustard, radish, and similar crops raised for sale in the bazaars. The cabbage crop suffers heavily, the plants being frequently badly attacked, the leaves spoilt, and the crop unsaleable. The cultivator's remedy of picking the larvæ is effective but very tedious. Better results are obtained with spraying and the simple tin hand sprayer made in the bazaar at a cost of rupee one annas twelve is eminently adapted for this work. The best insecticide is Messrs. McDougal & Co.'s Insecticide and Fungicide. Kerosene emulsion is effective and also pyrethrum powder (or Keating's insect powder) used as a stomach poison at the rate of 1 oz. to 1 gallon of water. Where such work is done intelligently, the use of lead arseniate is by far the best remedy, but owing to its poisonous effect if applied in excessive quantities this insecticide cannot be generally applied. Where spraying is not possible a dressing of ashes, applied by hand to the underside when the plants are wet, is effective in preserving the leaves from the caterpillars. A good and safe application is tobacco and soap or tobacco decoction, made by soaking refuse tobacco in cold water at the rate of 1 lb. to 5 gallons and adding soap suds made by mixing ¼ lb. soap in 1 gallon of water.

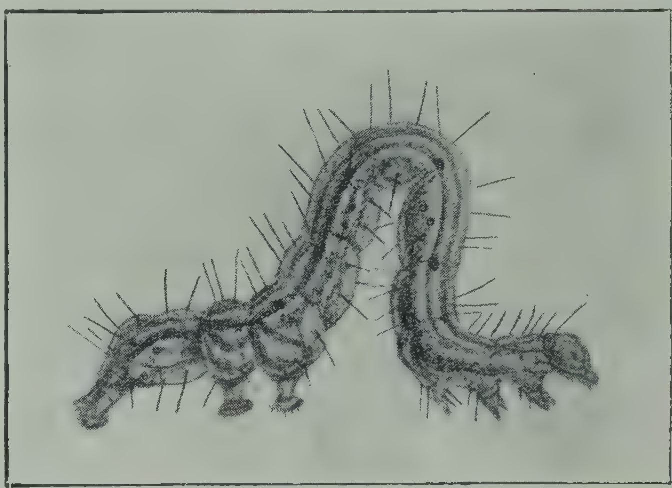

FIG. 172.
Semi-looper Caterpillar that eats cabbage.
(Magnified four times.)

FIG. 173.
Pupa of Cabbage Semi-looper, as found on cabbage leaf under a silken web.

Minor Pests of Mustard, Rape, etc.

Cruciferous plants also suffer from the attacks of other insects which are not specific pests but come casually. More than one species of caterpillar can be reared from mustard, cabbage, rape, etc., and the cabbage crop in particular suffers from the presence of green semi-looper caterpillars [1] which eat holes in the leaves. The mustard aphis is also a serious pest, attacking mustard, rape, sarson, etc., when grown as a rabi crop. This aphis appears first on the young plant, increases with enormous rapidity, and clusters on the pods and stems. A weak crop becomes exhausted and unable to bear seeds (page 237). The painted bug (page 233) is a very minor pest of these crops, in peculiarly favourable seasons becoming very abundant on late sown mustard.

Fig. 174.
Cabbage Moth.

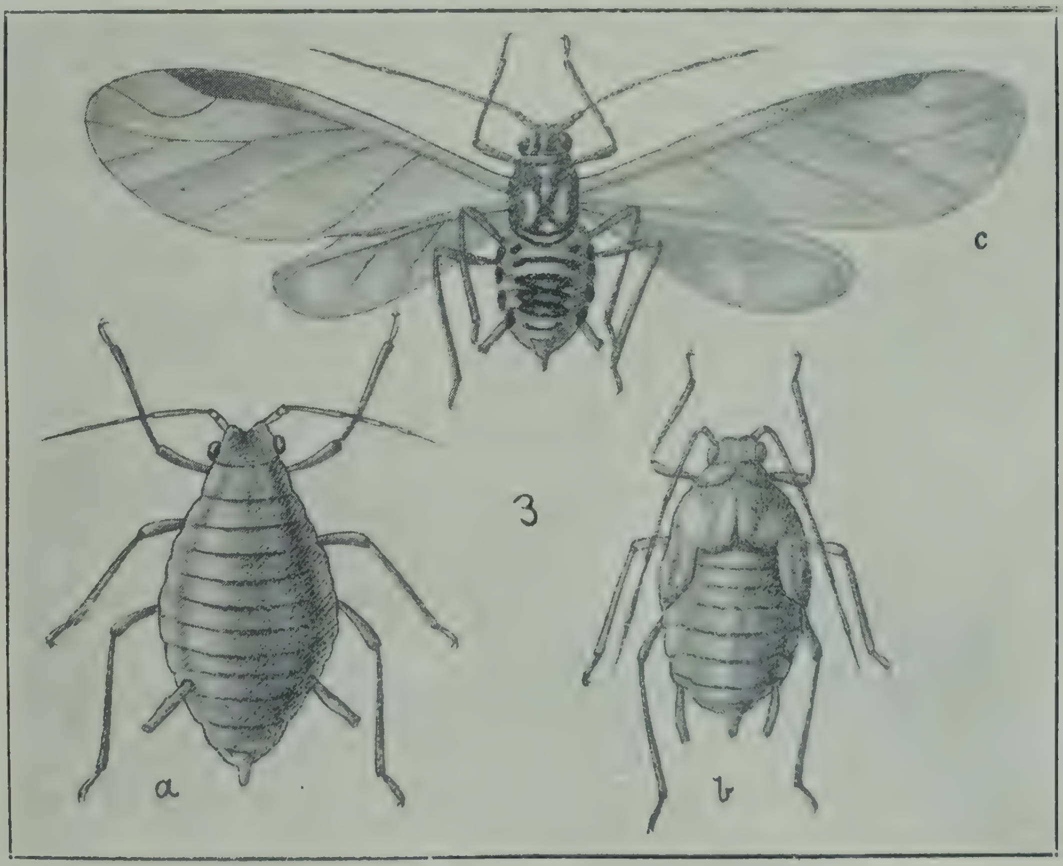

Fig. 175.
The Rape Aphis.
a, *Wingless female.* b, *Nymph.* c, *Winged female.* (*Magnified twelve times.*)

[1] 100. *Plusia signata.* F. (Noctuidæ.)

Tobacco Stem Borer.

The most serious pest of growing tobacco is a small whitish caterpillar, which is found tunnelling in the main stem, causing a peculiar gall-like swelling. The caterpillar enters at the axil of a leaf or tunnels down the mid-rib of the leaf until it reaches the stem ; apparently it hatches from an egg laid on the stem or on the leaf, but this egg has not been found.

Having entered the main stem, it tunnels in the tissues, which swell and undergo abnormal growth, producing a distinct and characteristic knot. Within this swelling the caterpillar lives until it is full grown, when it prepares an exit hole for the future moth and turns to the pupa inside. The moth[1] is a small brown insect, the wings narrow and fringed, not easily distinguishable from the many small moths of this family which are found in the fields.

Tobacco is a crop of which great care is taken during the growing period, so that cultivators are aware of this pest ; when they find this swelling, they make a cut into it with a knife, believing that the admission of air will destroy the insect.[2] Apparently the pest is not injurious in healthy vigorous tobacco but is worst in a season of drought. It is common in various parts of India and Mr. Green reports it from Ceylon. Where the pest is seen so late that the emerging moths could not produce a new generation in the tobacco, only plants that are useless should be removed and burnt. No treatment, except perhaps that of cutting open the plants, can check the insect in the stem. The pest can be looked for in experimental tobacco cultivation, where varieties are grown side by side and causes a considerable amount of harm under these circumstances.

Tobacco Caterpillars.

Leaf-eating caterpillars attack tobacco and a small number may do a large amount of actual damage by eating holes in the leaves. The most abundant of these is a dark brown caterpillar, common throughout India, which is the larva of a common moth.[3]

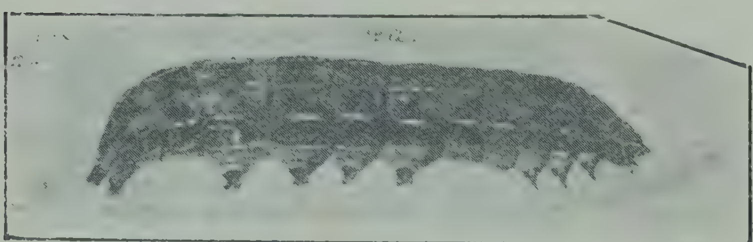

FIG. 176.
Tobacco Leaf Caterpillar.

[1] 76. *Gnorimoschema heliopa.* Low. (Tineidæ.)

[2] For this and other facts about Gujarat cultivators, I am indebted to Purushottam Patel, first fieldman.

[3] 53. *Prodenia littoralis.* Boisd. (Noctuidæ.)

The life history is similar to that of other moths, the eggs being laid on the plant, the caterpillars feeding on the leaves, the pupa lying in the earth without a cocoon, the moth lying hidden by day and emerging at dusk. In the hot weather or rains the whole life history is passed in about a month; the insect hibernates as a pupa or larva, emerging in March. If tobacco is not available, the caterpillar attacks a variety of crops and is a pest in gardens (see page 181).

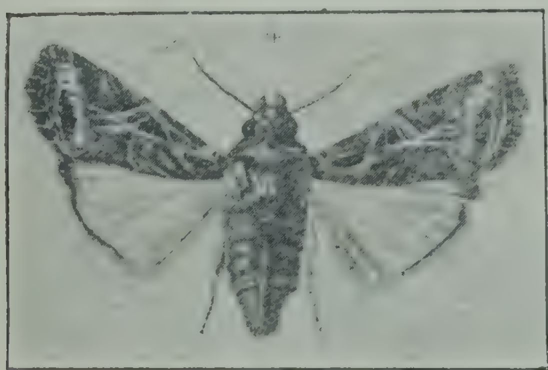

FIG. 177.
Moth of Tobacco Leaf Caterpillar.

Another species attacking tobacco is a green caterpillar, with a similar life history; it is a common insect in the plains, the moth[1] being closely similar to that of the Gram Caterpillar, both being of the same genus. When the tobacco is young, an application of lead arseniate does good, poisoning all caterpillars that feed on it. This application cannot be made to plants that have large leaves and are within a short time of ripening, as the arsenic might remain on the leaves. A fortnight before cutting is the very latest date on which arsenic can be safely applied. In such a case nothing but hand-picking is possible, and a careful watch must be kept for such caterpillars in the last growth of the tobacco plants.

Minor Tobacco Pests.

Surface grasshoppers are commonly found attacking newly set out plants of tobacco, eating the leaves and destroying the young plants. Even if the plants are not killed, the crop becomes very uneven. To check this the grasshoppers should be removed before transplanting; where possible the transplanted seedlings should be dipped in the lead arseniate mixture used to poison the leaves; the young plants grow quite well and regularly (page 220).

Crickets are also found attacking young tobacco, and where this is a valuable crop, the ravages of the large crickets may be important (page 224).

The seed capsules are eaten by several caterpillars, including the

[1] 158. *Chloridea assulta.* Guen. (Noctuidæ.)

omnivorous Gram Caterpillar (page 144). This form of attack may be watched for and the caterpillars picked off if seed is required, as these insects may soon clear a plant of the whole of its seed.

Castor Pests.

Castor is in general a healthy plant with few pests. Caterpillars are fond of it and sometimes come in vast numbers, clearing the plants of leaves in a very short time. Three species are represented, being totally distinct and easily recognised.

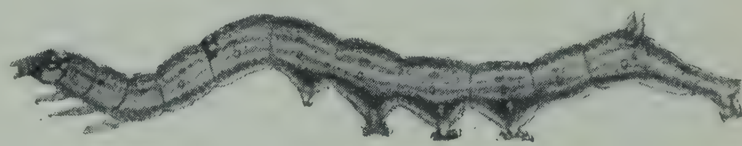

FIG. 178.
The Smooth Castor Caterpillar. (Magnified twice.)

The Smooth Castor Caterpillar is a long slender caterpillar of a dark colour, with longitudinal stripes of red and white; it has the usual five pairs of prolegs, the first being reduced in size; at the hind end there is a small blunt paired process on the dorsal surface. The caterpillar walks with a semi-looping motion. This caterpillar pupates in a fold of the leaf in a light cocoon. The life history is short, occupying about five weeks and there are several broods in the year. The moth [1] is figured here; it is common throughout India and the caterpillars often appear in hordes, strip the plants and disappear. The Hairy Caterpillar also feeds upon the leaves and is found in clusters at the base of the stem from whence it climbs up the plant to feed. The full grown insect is over two inches long, clothed in dense hair and looking like a piece of blanket. This caterpillar is not so abundant as the former species and has other food-plants. It pupates in a cocoon formed of the hairs of the larva, the moths [2] that emerge being green or yellow, the male much smaller than the female. The Spiny Castor Caterpillar is a green caterpillar, the body covered with branched spines, the head with two long processes bearing spines. It feeds upon the leaves of the plant, and pupates by hanging itself from the leaf; the pupa is greyish brown, with a flat hood-like

FIG. 179.
Moth of Smooth Castor Caterpillar showing upper and lower surface of wings.

[1] 52. *Ophiusa melicerte.* Dr. (Noctuidæ.)
[2] 205. *Trabala vishnu.* Lef. (Lymantriidæ.)

structure on the back, similar to other butterfly chrysalides. The imago is a deep brown butterfly,[1] common throughout India (fig. 180).

These three species attack castor at almost all seasons of the year. When the eggs are laid and the caterpillars hatched, nothing can be done but to destroy that brood by picking and burning the infested leaves. The increase of these insects is rapid and, if allowed to multiply, they may come in such vast numbers as to entirely strip the plants. The smooth caterpillar is the worst as it feeds upon many wild plants and suddenly appears in numbers out of the jungles, eating every plant it can find: having finished the castor, it starts upon other crop plants. Like other Noctuid caterpillars, this species feeds voraciously and quickly; the life history is short and the reproductive powers of the moth large. Compared with it, the Hairy Caterpillar is harmless, being slow in its life history and having few broods in the year; and the spiny butterfly caterpillar is a rarer insect, that appears constantly but does not multiply at the enormous rate of its successful cousin.

FIG. 180.
Castor Butterfly.

Another pest of castor is a small caterpillar found boring in the capsules, destroying the seeds. It does a considerable amount of destruction when well established and is found abundantly in late ripening castor. The caterpillar is easy to rear, a small bright yellow moth[2] emerging, which is speckled with black. The chief safeguard is in leaving no stray plants for the pest to breed in; where the crop of castor comes on evenly the pest can do little harm. When some ripens early or is sown early, or when stray plants are left in the fields and bear at unseasonable times, the pest increases. It is best to sacrifice the early capsules, picking them off and destroying them.

Til Sphinx.

A large green caterpillar, with oblique yellow stripes on the abdominal segments, is found feeding upon the leaves of *til* (sesamum) during the cold weather. It has a large horn on the hind end and grows to a length

[1] 156. *Ergolis merione.* Cr. (Nymphalidæ.)
[2] 161. *Dichocrocis punctiferalis.* Guen. (Pyralidæ.)

of over two inches. This pest has been found in the Central Provinces attacking the cold weather *til* and appears to be fairly abundant in some seasons. The life history is similar to that of other moths of this family.

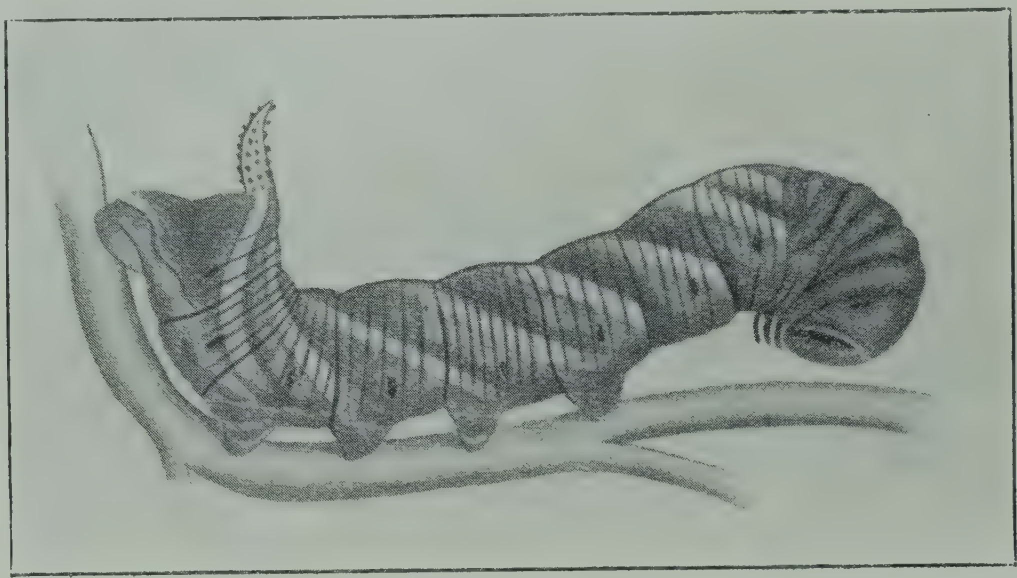

FIG. 181.
The Til Sphinx Caterpillar. (From Moore.)

The eggs are laid singly on the leaves of the plant, rather large rounded eggs of a greenish white colour. The caterpillars hatch, feed upon the leaves of the plant and rapidly grow larger. The larval life is peculiarly long, occupying about two months, during which the caterpillars increase in size till they are very large and conspicuous. The full-grown caterpillar is a bright green with eight oblique yellow stripes on each side; the body tapers towards the head and the anterior segments can be retracted with

FIG. 182.
Til Sphinx. Empty pupa case from which the moth emerged, below.

the head drawn in, giving the insect a very striking appearance. The large anal horn adds to the curious effect, which accounts for the belief that the caterpillar is venomous. Actually it is absolutely harmless and safe to handle. When full fed the colour changes to a deep brown, and the caterpillar then leaves the plant to find a suitable place in which to enter the soil.

This change of colour is protective, the green colour hiding it when on the green plant, the brown colour when it is on the ground searching for a suitable spot. It buries itself in the soil, appearing as a pupa after a period of rest. This is a large chestnut brown insect, smooth and shiny; the figure shows the empty pupa case from which the moth above emerged. The pupal period lasts for two, three or more months. The moth is one of the larger hawk moths,[1] closely related to the 'death's head' moth of Europe. The head and thorax are dark, the latter with the 'death's head' mark, the abdomen is yellow with black bands and a dark stripe down the middle, the fore-wing is mottled in brown and grey, the hind-wing yellow with black bands.

The larger specimens measure nearly four inches across the expanded wings; the moths are very swift in flight, emerging at dusk to fly about and seek the flowers from which they obtain nectar.

This species has also been found on val (*Dolichos lab-lab*) and has alternative food plants. It is found throughout the plains of India, not as an injurious pest but as a common insect; it has a wide distribution outside India. The best treatment is to pick the caterpillars by hand; they are large and conspicuous, can be easily collected and are most simply killed in water.

Minor Pests of Til.

A small white caterpillar, black speckled and with a touch of creamy green, is found feeding on the leaves or the pods of til. It is not common, though widely spread in India and has not been reported or found as a serious pest. It is the larva of a small red moth[2] less than one inch across the expanded wings, which extends over Europe and Asia. Another

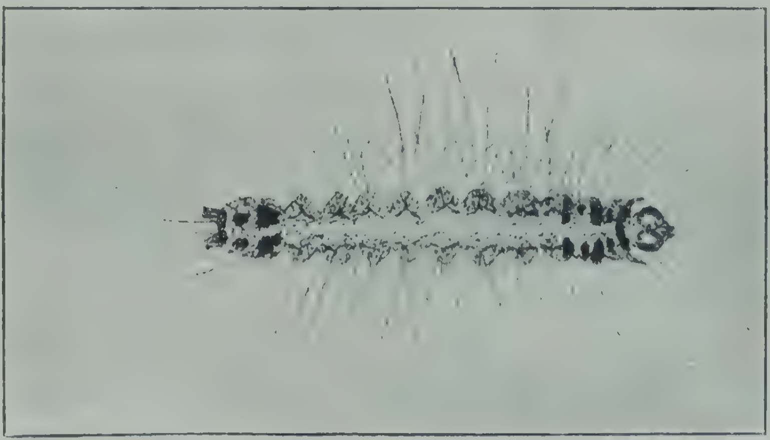

FIG. 183.
Hairy Caterpillar of Bihar. (*Slightly magnified.*)

[1] 193. *Acherontia styx.* Westd. (Sphingidæ.)
[2] 111. *Antigastra catalaunalis.* Dup. (Pyralidæ.)

pest is the hairy caterpillar (fig. 184) which devours so many crops.

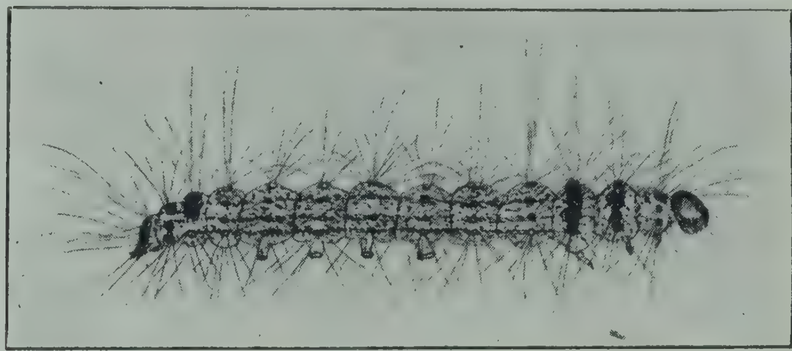

Fig. 184.
Hairy Caterpillar of Bihar. (*Slightly magnified.*)

No other pests have been found affecting this plant, though doubtless others remain to be discovered.

CHAPTER XIII.

PESTS OF VEGETABLE CROPS.

IN this chapter the pests of all vegetable crops will not be treated in detail; some few pests that deserve individual mention will be grouped together. In small areas of vegetable crops the pests of field crops also occur; radishes in a garden are damaged by the same pests as rape and mustard in the field. Above all, numbers of occasional pests occur in small areas of garden crops; leaf-eating caterpillars are numerous, plant lice and mealy bugs abundant; the brown ants eat the cauliflowers, cockchafer grubs eat the roots of any plant, and so on. Such numbers of insects attack a vegetable or market garden that they cannot be discussed in detail here.

Sweet Potato Weevil.

A small weevil,[1] very narrow in outline, with a conspicuous straight beak, coloured in red and blue, is found in sweet potato tubers in the ground. All stages may be seen in the tuber and the beetle is quite characteristic.

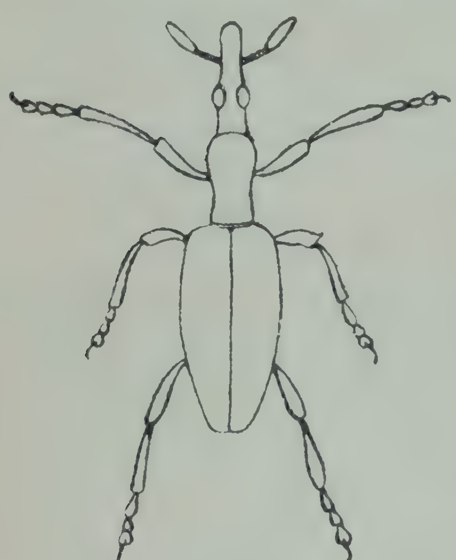

FIG. 185.
The Sweet Potato Weevil.
(Magnified four times.)
(From Tryon.)

This is almost the only known specific pest of sweet potato in India, a cosmopolitan pest found throughout the tropics. The weevil lays eggs singly on the tubers, hatching into a small white legless grub which at once tunnels into the potato. The grub eats its way in the potato, filling the tunnels with excrement and setting up decomposition.

The pupa is found in the potato, in a small cavity closed at each end with particles; the imago when it emerges eats its way to the surface and escapes.

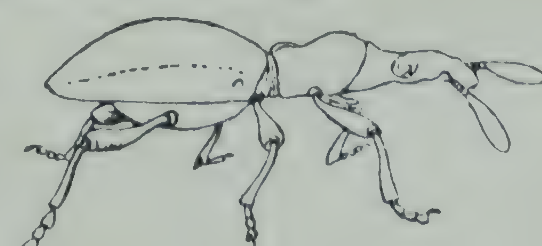

FIG. 186.
The Sweet Potato Weevil.
(Magnified four times.)
(From Tryon.)

The whole life history occupies about one month; the broods succeed one another quickly and the pest continues to increase so long as the weather is warm. The tubers are attacked in the field, the beetle laying eggs in the thick stems on the tubers. A badly infested plant becomes weak and stunted, the

[1] 7. *Cylas turcipennis.* Bohm. (Curculionidæ.)

stems swollen and the leaves small. The symptom is one recognisable to the trained eye, but not easily distinguished from the appearance of an unthrifty stunted crop. An examination of the tubers on the main stems reveals the pest at once, even if the beetles are not seen upon the leaves.

The result of the attack is that the tubers are converted into a decaying mass unfit for food. A tuber on being cut exhales a peculiar sharply aromatic odour, and the tissues round the tunnels darken when exposed to air. If left alone the insect reduces the whole tuber almost to dust. Tubers even lightly infested are unfit for human food; they may be crushed and fed to cattle if not too much attacked.

When a crop is once infested, nothing can be done to check the pest; the infested potatoes must be destroyed to prevent the insect breeding. Sweet potatoes should not be grown twice running on or near infested land; the pest must be starved out. Equally when a crop is infested and spoilt, the whole crop must be dug; small infested tubers left in the ground afford a breeding place to the beetle and it is thus able to attack the next crop. As a rule, a crop which grows deeply is not attacked, and the beetles lay eggs only in tubers exposed on the surface. A deep rooting variety should be grown where the beetle is prevalent and every precaution must be taken to ensure the total destruction of an affected crop.

Pests of Melons and allied Plants.

Melons, cucumbers, pumpkins, and the like are moderately immune from pests, no very important ones having yet been found. The Melon Fruit Fly is discussed elsewhere (page 170); the best remedy against this pest to melons in Baluchistan and the Punjab is to bury the young fruits in the earth, as is now done, or to protect them by means of muslin bags from the egg-laying flies. In India generally, pumpkins, melons and all forms of cucurbitaceous fruits suffer from similar flies but not to any serious extent. The maggots are found in the fruits here and there; the flies laying their eggs in the young green fruits. For all these, care in the destruction of infested fruits is the rational check on their increase and a maggotty fruit should never be left to rot on the ground and breed flies as is so often done.

The *Epilachna* beetles are common pests on pumpkins, etc.; they are universal in India, feeding normally upon wild plants and multiplying slowly on the crops. They are discussed separately (page 204).

The Red Leaf Beetle[1] is the most general pest of these plants (fig. 233, page 200); it is found in all varieties, the beetle feeding among

[1] 11. *Aulacophora foveicollis.* Kust. (Chrysomelidæ.)

the leaves and damaging the young plants. This beetle is perhaps the most common and abundant insect in the plains, met with wherever there is a cucurbitaceous plant. Its life history is still unknown. Well-established plants that are growing freely do not suffer from this pest, but it eats young plants completely. Lead arseniate is the direct cure, but an occasional dose of kerosene emulsion to make the leaves nasty, or a liberal dusting with ashes or lime and kerosene keeps away the beetles for the time being.

With the red beetle is a very similar insect [1] with blue black wing covers (fig. 234, page 200); this is rarer but still fairly common and behaves just as the red beetle does.

Among other pests the Banded Blister Beetle (fig. 241) is common on the large flowers of these plants, feeding on the anthers and sepals. It looks a far worse pest than it really is, as the destruction of the flowers really does not matter.

A single caterpillar is abundant upon these plants, behaving as an ordinary leaf caterpillar. This is a slender green caterpillar, marked by a stripe of white on each side of the mid-dorsal line, and a spot of black on the first two segments; it grows to a length of one inch and pupates on the lower surface of the leaf under a thin webbing. The moth [2] is white with a broad band of black on the edge of the wing (fig. 187). When very numerous this is a destructive insect, riddling the plants in a short time. Where possible a good application of lead arseniate should be applied. In other cases, only laborious methods of hand picking can be used.

FIG. 187.
Moth of Pumpkin Caterpillar.
(*Twice magnified.*)

Caterpillar Pests of Brinjal.

Three species of caterpillar attack the brinjal plant (*Solanum melongena*) working in similar ways but belonging to three distinct groups of moths. It is difficult to distinguish these in the caterpillar stage and we may consider them together.

[1] 125. *Aulacophora excavata.* Baly. (Chrysomelidæ.)
[2] 112. *Glyphodes indica.* Saund. (Pyralidæ.)

These caterpillars bore tunnels in the stems and branches of the plant, living inside and feeding upon the tissue of the plant. They are whitish coloured insects, smooth and generally similar to other borer caterpillars. The eggs from which they hatch are deposited upon the plant singly, and the little caterpillar at once bores into the stem. When full grown the caterpillar pupates, making a cocoon for itself on the plant, on the ground or more rarely in the tunnel of the stem. The pupa stage lasts from eight to twelve days in warm weather and the moths emerge. The whole life history occupies about one month in the warm weather and up to three months in the cold. These moths are of very distinct appearance; one[1] is a small brown insect, with narrow fringed wings and sharply upturned palps; it superficially resembles moths such as the Pink Boll-worm moth (page 94) or the Cotton Bud-worm moth (page 100). We may call this the moth of the stem-borer caterpillar, since the caterpillar is principally in the main stem. The other moths are both white; one[2] (fig. 189) has brown and black speckles on the wings, and the larva has a rather pinkish colour (fig. 188); it is found commonly in the fruit of the plant and we may call it the "fruit borer." The other[3] is slightly smaller white, with a broad green blotch on the wing. It is a quite distinct insect and easily recognised. Its larva bores only in the upper branches of the plant, tunnelling in the soft shoots. We may call it the "shoot-borer."

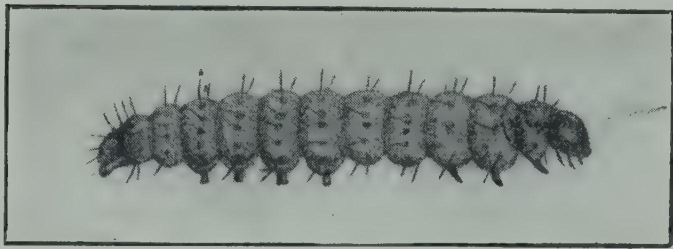

FIG. 188.
Brinjal Fruit Borer. (Magnified three times.)

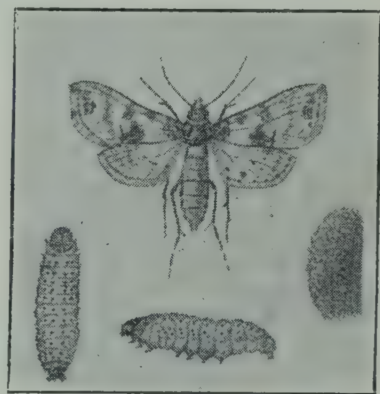

FIG. 189.
Brinjal Fruit Borer.

The stem-borer is found principally in the lower part of the stem near the ground; it attacks plants at all stages and is a serious pest. Where brinjal is grown as a long crop, quite thirty per cent. of the old plants may be attacked and killed; the plants wither suddenly when the larva cuts through the cambium layer of the main stem; such withered plants are common in the fields when the crop has been growing for some months. The shoot-borer is a comparatively harmless insect,

[1] 2. *Euzophera perticella.* Rag. (Pyralidæ.)
[2] 109. *Leucinodes orbonalis.* Guen. (Pyralidæ.)
[3] 154. *Eublemma olivacea.* Wlk. (Noctuidæ.)

only destroying isolated branches and not killing the whole plant. The fruit-borer attacks the fruits as they ripen and also the shoots; it is perhaps the most common and widespread of these three species.

The treatment of all these is the same, namely, destroy all affected fruits and branches. In the case of the stem-borer, the cultivator pulls up the withered plants and leaves them in his field. If he burnt them systematically from the very beginning, he would probably check the pest, but actually it increases steadily as his plants grow bigger until it causes a very large aggregate loss.

The same applies to the affected fruits and branches; it is common to see the bored fruits left on the ground or on the plant, and naturally every moth hatching from them means more in the next brood. A useful precaution where brinjal is regularly grown, is to destroy the wild brinjal and allied solanaceous weeds which spring up in the rains; these are the wild food-plants of these species and help it to increase and multiply unchecked.

Bhindi Pests.

This plant (*Hibiscus esculentus*) is closely related to cotton, and to many plants grown in gardens for ornament. It is universally grown in India as a vegetable, a few plants here and there in every village, and also as a field crop mixed with other plants.

It has many pests, almost as many as cotton, the pests of cotton attacking it as an alternative food-plant, the pests of wild malvaceous plants coming to it as it offers plentiful food when other food is not available. The Cotton-leaf caterpillar (page 96) is abundant on the leaves, webbing them across and living under the threads. It does not as a rule twist the leaves up as it does on cotton. At least three other caterpillars feed on the leaves, two being peculiar pests of malvaceous plants; these emerge into moderate sized light yellow moths,[1] the wings marked with dark brown suffusions.

The White Weevil and Green Weevil eat the leaves of bhindi as they do of cotton and other crops (page 202). Both the Spotted Boll-worms also attack bhindi, the larva boring into the pods or into the succulent stems. The Red Cotton Bug (page 104) lives upon bhindi when cotton is not available, feeding upon the seeds and breeding freely upon these plants. So also the Dusky Cotton Bug (page 107) is found in the old open pods, sucking out the seeds.

In spite of all these pests, bhindi grows freely and yields well. A little attention on the part of the cultivator checks the insects, but as the

[1] 58. *Acontia transversa.* Guen. (Noctuidæ); & 117. *Acontia malvæ.* Esper. (Noctuidæ.)

crop still comes, in spite of the pests, no attention is paid to them. This is unfortunate, as these insects on bhindi are also the pests of cotton which do much harm.

Pests of Ginger.

Two pests have been found attacking ginger in Bengal, neither seriously. The ginger maggot is a white fly maggot found tunnelling in the rhizome of the growing plant; these maggots resemble the usual fly maggots, being small headless white insects, with mouth-parts in the form of hooks. They tunnel in the tissues, killing them and setting up decay. The pupa is found in the rhizome and the fly is found walking on the leaves of the plant. The fly [1] is a noticeable insect, with long legs, a long narrow body and wings; such flies are not uncommon but can be seen in any number on ginger plants. The rhizome should be examined for maggots and any diseased ones destroyed.

The ginger caterpillar is a green caterpillar, with a dark head, of the typical "skipper" form, which lives upon leaves, folding one over and lying hidden inside the fold. The pupa is also found on the leaf and a prettily marked butterfly [2] emerges. As a rule one caterpillar is found on each plant, the butterfly laying her eggs one at a time. The pest is easily checked by hand picking, the caterpillars and pupæ being found in the large folded leaves.

Potato Pests.

The only specific pest of potato recorded is the very common green bug,[3] a cosmopolitan insect which sucks the juice of the plants and is found commonly on them. It is a common insect in the hills and is readily checked by hand-picking.

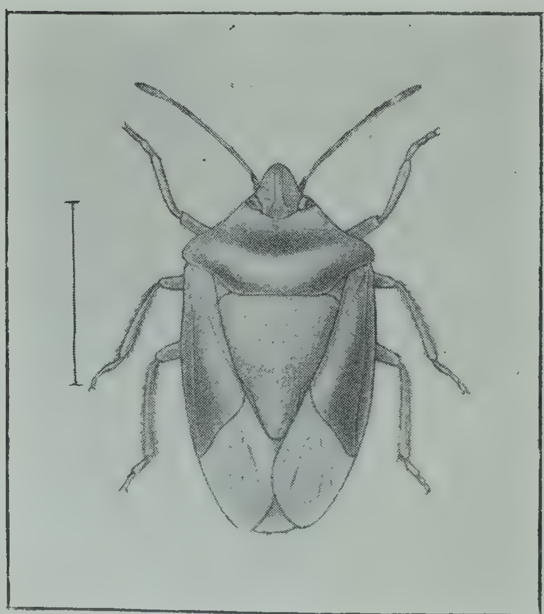

Fig. 190.
The Green Bug. (Magnified.)

A boring caterpillar has been reared from potato plants in Dharwar which is the Brinjal Fruit-borer (page 166). A somewhat serious pest in Bengal is a mealy bug which attacks the stored seed potatoes, and apparently causes them to rot. Seed potatoes infested with this bug cannot be preserved until the next season. The treatment is very simple and lies in storing the

[1] 211. *Calobata* sp. (Muscidæ acalyptratæ.) | [2] 215. *Udaspes folus.* Cram. (Hesperiidæ.)
[3] *Nezara viridula.* L. (Pentatomidæ.)

potatoes in ashes or other dry powder, or in examining them periodically and, if infested with bug, dipping them in a weak insecticide such as kerosene emulsion. A mixture of ash, lime, flour or other powder and kerosene dusted over stored potatoes will preserve them by destroying the bug.

CHAPTER XIV.

PESTS OF FRUIT.

Fruit Flies.

THROUGHOUT the tropics, ripening fruits are infested with the maggots of flies, which burrow in the soft tissues and render the fruit valueless. Such flies are of far greater importance in other parts of the world than in India, possibly owing to the different manner in which fruit culture is conducted in India. Several species are known in India, the Melon Fly of Baluchistan and the Punjab,[1] the Peach Fly[2] of

FIG. 191.
The Mango Fly. Larva on the right. (Magnified.)

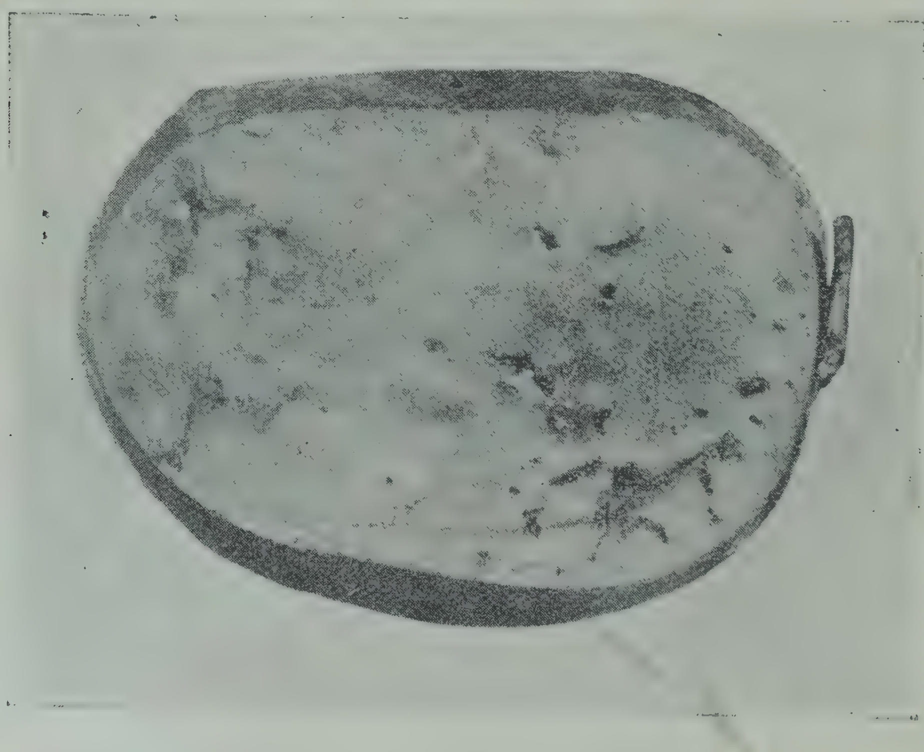

FIG. 192.
Mango fruit infested with maggots.

[1] 218. *Carpomyia parctalina.* Big. (Trypetidæ.) | [2] *Rivellia persicæ.* Big. (Trypetidæ.)

Ranchi, and the Mango fly [1] of Behar, the United Provinces and other parts of India being the more important species. There are in addition species which attack the brinjal, the turia, the various melons and gourds, the fruit of the akh (*Calotropis* spp.) and other wild plants. These insects cannot be said to be known as serious pests; they may be so, as the cultivators do not report such attacks and it is only rarely that they can be investigated. The mango fly is perhaps best known, as it attacks a fruit of general consumption and is noticed by many persons.

FIG. 193.
The Peach Fly. (Magnified.)

The life history of fruit flies is generally as follows: the female lays eggs in the tissue of the fruit, piercing the rind by means of the ovipositor, the sting-like continuation of the abdomen. A number of small white eggs are laid, which hatch in a few days to tiny white maggots. The maggots live on the pulp, making tunnels through it and perforating it in all directions. This period lasts about ten days, and the maggot then leaves the fruit and enters the earth, where it becomes a pupa. From this the fly emerges after the lapse of about a week. The details of this life history vary for different fruit flies, but such are the salient facts.

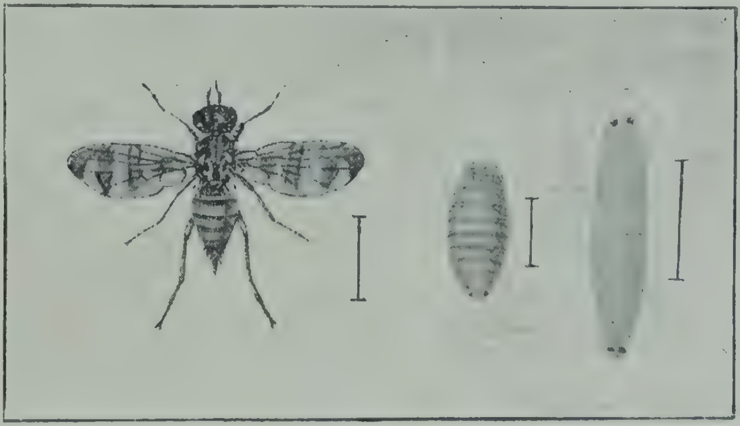

FIG. 194.
The Baluchistan Melon Fly. Larva on the right, pupa in the middle. (Magnified.)

The melon fly is injurious in Baluchistan and the Punjab; its life history has been recently worked out.[2] The female lays one or several eggs (4-7) singly or in batches on the rind of the fruit in the early hours of the morning, a very young fruit being generally chosen for oviposition. The eggs are white, oval and elongate, hatching in 4 to 5 days. The small white larvæ at once bore into the fruit; as they proceed into the pulp, the

[1] 129. *Dacus ferrugineus* Ol. (Trypetidæ.)
[2] Report of Lala Vishwa Nath Sahai, Entomological Assistant, Punjab.

passage fills up behind them and a few days after the maggots have reached the inner pulp, the hole in the rind closes completely up. When several maggots are contained in a single fruit, it gets stunted and dies; if the number is only three or four, the fruit decays only if the maggots bore out through the rind.

When full grown the maggot is about half an inch long; it pupates in the fruit or, if the fruit is much eaten or decayed, in the soil. Pupal life lasts for 13 to 18 days, the whole life history occupying one month. There are two broods in the melon crop, the first a small one, the second very large.

This account of the melon fly is typical of the whole group, with small distinctions. As a rule eggs are laid in the fruit, not on the rind. The critical point in the attack is the first brood; if the first flies can be prevented from laying eggs or the first larvæ destroyed, the immense second brood is checked.

These flies have been very carefully studied in other parts of the world where they are very serious pests. We have, therefore, the experience of other countries to guide us in our attempts to check the pest. Actually two measures only can be advised which are adopted elsewhere. It may be taken for granted that once the fly has been allowed to lay eggs, the infected fruits are doomed. No possible treatment can destroy the maggots in the fruits. Also there is no method of destroying the flies on a large scale and so killing them before the fruits ripen. It is possible to prevent the flies from laying eggs by the use of netting. The flies only lay eggs on ripening fruits and in South Africa the fruit trees liable to attack are covered in cheap mosquito netting of a fine enough mesh to keep them out. This simple remedy is practicable where the value of the crop to be saved exceeds the cost of the netting.

In addition, it is clearly wise to check the increase of the flies themselves in the fruits. The early ripening fruits are naturally first attacked and from them comes the large second brood that attacks the main crop. Every fruit that falls from the tree, and every fruit that is found to be infested, should be destroyed to prevent the flies emerging and multiplying.

At the present time an effort is being made by entomologists abroad to utilise the natural enemies of these flies and introduce them to places where they do not at present exist. Up to the present there appears to be no reason to anticipate much practical result from this method until a far greater amount of investigation has been made.

For the Indian species, this line of enquiry cannot be entered upon until more is known of fruit flies in general. Very few enemies of fruit flies are known in India and very little is on record of the habits or distribution of the species discovered. As in other cases, if the cultivator would take an interest in his pests, seek for all infested fruits and destroy them, much would be done towards checking them. As a rule infested brinjals, for instance, are plucked and allowed to lie on the ground near the plant, the natural result being that the pest is encouraged and allowed to multiply unchecked. The same applies to other crops; maggotty mangoes lie on the ground and rot, breeding a fine large brood of flies which lay eggs in every late mango fruit.

Mango Hoppers.[1]

Mango trees suffer from the attacks of small insects, which we may call hoppers, which infest the flowering shoots of the tree. These insects resemble the *Cicadas* superficially but are much smaller being one-sixth of an inch in length. They are somewhat wedge-shaped with wings sloped at an angle over the back. Large numbers are found on the mango trees throughout the hot weather but especially at the flowering season when there is a flow of sap to the flowering shoots. These insects pass through their active life on the tree, sucking the juice of the soft shoots and causing them to wither. The cast skins may be seen in abundance on the under surface of the leaves of the tree. The insects when young jump actively, when full grown fly out from the leaves when disturbed. They are rarely plentiful, and their increase appears to be assisted by damp winds, such as the east winds of Behar which in some seasons blow in February and March. The result of this increase is seen by the withering of the flowering shoots and consequent failure of the crop. Like other sucking insects these insects excrete large quantities of sugary fluid, which falls upon the leaves below and dries, leaving a sticky shiny deposit. When abundant, immense quantities of this fluid fall, which is a symptom of the disease. There is only one effective treatment which must be adopted vigorously; this is spraying with strong contact poison such as crude oil emulsion or sanitary fluid; a large spraying machine fitted to a barrel with a good length of hose fixed to a bamboo should be used so as to reach high up the tree, and the spraying should, if possible, be done before the flowers open.

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[1] *Idiocerus* spp. (Jassidæ.)

The Mango Weevil.[1]

In many parts of India ripe mango fruits are found to be spoilt by the tunnels of an insect which, emerging from the stone, eats its way out through the pulp. The insect is a short, thick-set weevil, dark brown in colour, one-third of an inch in length. When disturbed it draws its legs together and lies motionless, feigning death. The grubs bore in the kernels of the mango fruit when it is growing large; these grubs pupate inside the fruit and as the mango ripens, become beetles, eating their way out through the pulp of the fruit, which they spoil. The beetle hides at once in the bark of the mango tree, either in a natural crevice or in a hole prepared by itself. The beetle remains in this position apparently until the next season and there is, therefore, but one brood in the year.

The weevils remain alive for very long periods and are capable of living until the next year when they lay eggs on the mango flowers or young fruits. Weevils have been found throughout the year on trees whose fruits were infested and it is certain that they can live over till the following year. They also remain in the soil and not always on the bark of tree. The treatment of this pest will depend upon two precautions: destroy all infested fruits with the insects, and destroy the weevils on the bark of the mango tree in August. The weevils can be found on the bark of mango trees, which accounts for the fact that year after year the same tree is affected; the weevils come out of the fruit, and stay on that tree till next year, not flying or moving away. The bark of trees which bear infested mangoes should be well washed with strong kerosene emulsion or other contact poison, with a view to destroying the weevils found there; this has not been tested as yet but is worth a trial. A further precaution consists in thoroughly cultivating the ground under the trees, so as to destroy the weevils. Rai Bahadur B. C. Basu has found that when the land below infested trees is flooded, the trees are not infested in the following year.

The Lemon Caterpillar.

Lime, lemon, orange and other citrus trees are defoliated by curiously marked caterpillars, which feed openly upon the leaves of the plant. These caterpillars hatch from small round yellow eggs, laid a few at a time upon the topmost shoots of the plants, where the young caterpillars will find tender leaves upon which to feed. They are at first brown

[1] 204. *Cryptorhynchus mangiferæ.* F. (Curculionidæ.)

with white markings, closely resembling the droppings of birds, and doubtless feed on the leaf in an exposed position to assist the resemblance. The head is provided with two processes. When nearly full grown the

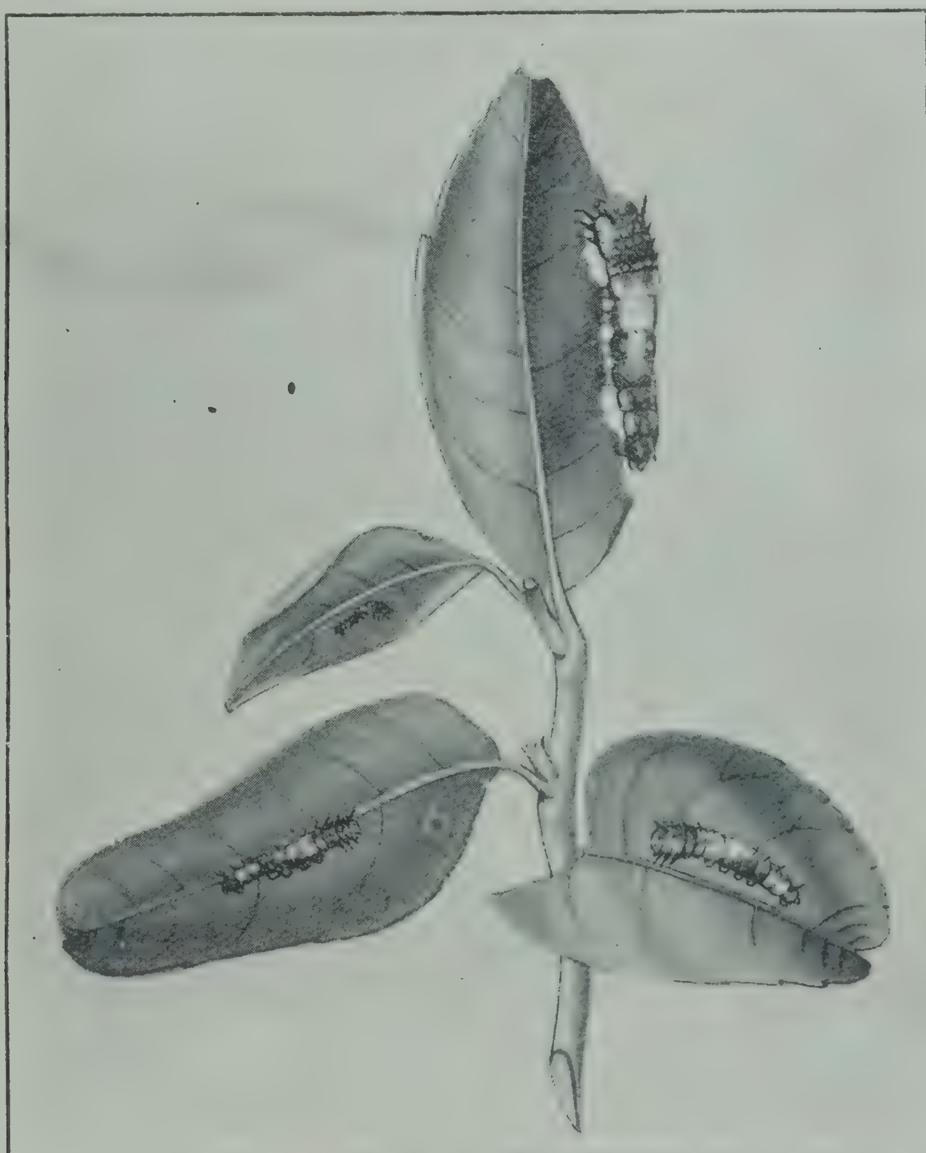

Fig. 195.
Lemon Caterpillar, feeding.

colour changes to a vivid green, with lateral brown markings and the caterpillar now leaves its exposed position on the leaf; when young they feed on the quite small leaves, attacking larger ones as they grow older. As a rule only a few are found on each plant but they do much mischief to small plants and, if abundant, entirely strip them. The caterpillar pupates on the plant, fixing itself by the tail and by a thread round the body which is fastened on each side to the plant. The butterfly[1] is large and conspicuous, common throughout the plains (figs. 196 and 197).

[1] 39. *Papilio demoleus*. L. (Papilionidæ.)

It lays its eggs also on the *ber* (*Zizyphus jujuba*) and other wild plants.

Fig. 196.
Chrysalis of the Lemon Caterpillar.

There are several broods in the year, the first in April, the second in June, the last in November, but there is also a brood in December in places where the cold is not too great. The simplest method of dealing with this pest is to pick off the caterpillars and destroy them. The

application of lead arseniate is effectual, but as there is usually a succession of egg-laying females, one application is not sufficient, and it is simpler to pick them by hand. Another butterfly[1] with an almost

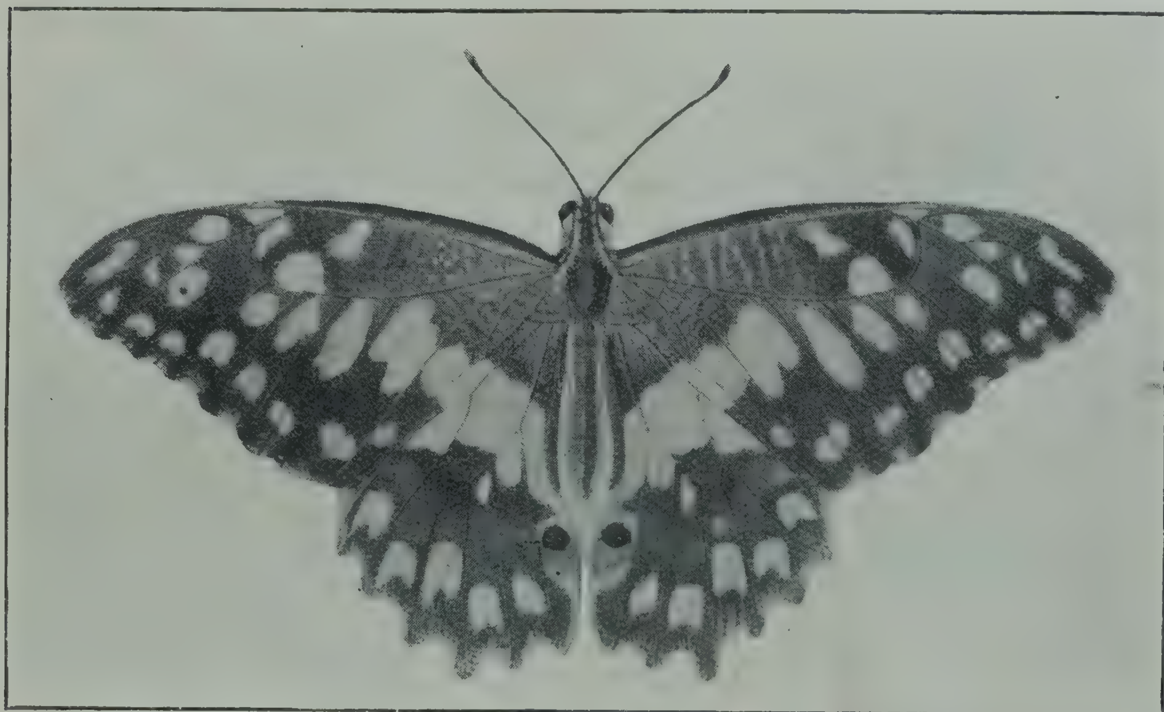

FIG. 197.
Lemon Butterfly.

identical life history is found attacking citrus plants but is apparently less common.

Insect Pests of the Orange.

Orange and other citrus trees all the world over are infested with scale insects and mealy wings, some being extremely virulent pests. These are not lacking in India, though they do not work a tithe of the damage caused elsewhere. In the Himalayas as in Calcutta, the leaves are covered with a small yellowish oval scale[2] from which a mealy-wing fly emerges; in Western India, a black oval scale takes its place, belonging equally to the mealy-wings. Both these species weaken the plant, extracting the sap and slowly killing the branches. True scale insects also infest these plants but they are apparently rarer. For these pests there is nothing better than a good spraying with a rosin wash; the whole plant must be carefully sprayed especially the under-surface of the leaves.

Another pest of the orange is a large moth,[3] which pierces the rind of this and other fruits with its powerful proboscis in order to extract

[1] 195. *Papilio pammon* L. (Papilionidæ.) | [2] *Aleurodes eugeniæ.* var. *Aurantii.* Mask.
[3] *Ophideres fullonica.* L. (Noctuidæ.)

the sap. The insect is a handsome one, the upper wings coloured in tones of grey, to resemble tree bark, the lower bright orange and black.

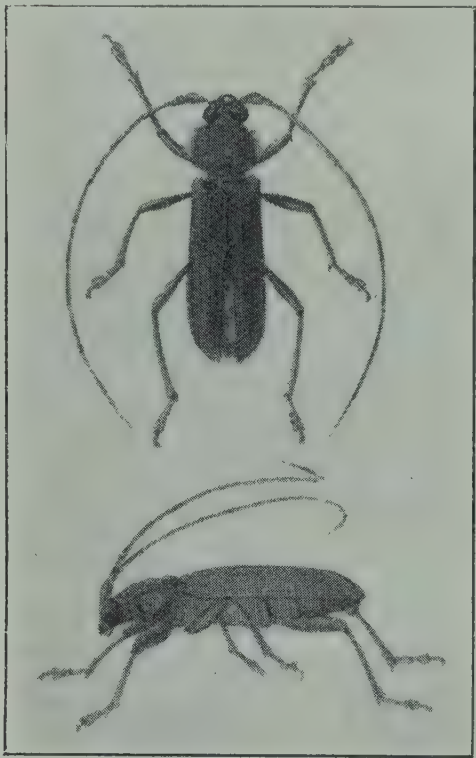

Fig. 198.
A typical Tree-boring Beetle.

By day this insect hides on the bark of trees, with the wings folded, coming out at dusk to fly about. It is attracted to fruit, feeding on the juices. This insect, like many others, comes into houses at night and can probably be trapped by putting up a lantern in front of a vertical white sheet, the broad white light attracting it. This would bring it to settle on the sheet when it could be killed. An alternative possible method is to give it food in the form of jaggery made into a syrup with water, mixed with a little country liquor or other intoxicant. Both of these devices are common ones among moth collectors and worth trying against this pest when the oranges are ripe. As the larva lives upon wild plants in the jungle, nothing can be done to check it.

Stem-borers are reported to injure oranges in India and may be found attacking the trees. Such borers are the grubs of beetles; the beetles lay eggs on the bark, the grubs on hatching boring through the bark into the trunk. They live in the trunk and attain to a great size before pupating, eventually coming out as beetles. The beetles are long, slender, with very long antennæ. Two species are known from lime and orange trees in Assam and Coorg, and others are known from fruit trees, coffee, tea, etc. The successful treatment of these insects consists in catching the large beetles when this is possible, destroying the grubs in their burrows by means of a bent wire, or by means of injecting carbon bisulphide, kerosene or other fluids into their burrows, which must then be closed up with wet clay or tar.

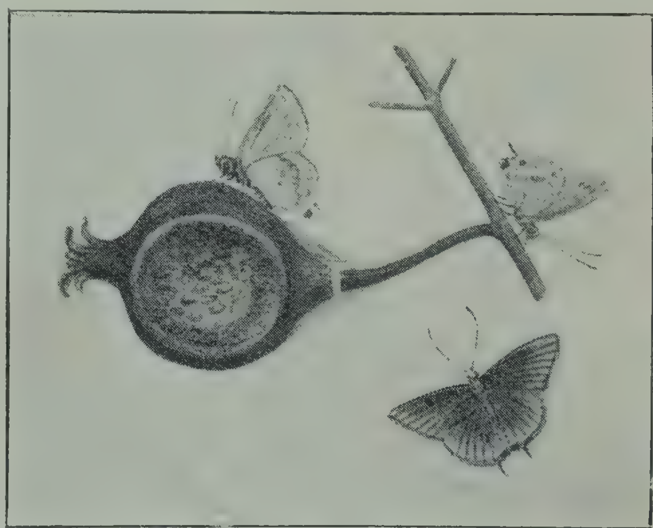

Fig. 199.
The Anar Butterfly.

The Anar Caterpillar.[1]

The cultivator of the pomegranate (*anar*) is familiar with the fact that a proportion of the fruit is destroyed by this pest; in a bad season the proportion is very high; in normal seasons small. At the time of the blossoming of the fruit tree, the female butterfly deposits the eggs singly on the flowers. The caterpillar hatches and bores into the developing fruit, within which it lives. The food consists of the hard seeds of the fruit. The larva is of a dark colour, with short hairs and lighter patches of colour; the hind end is flattened above, forming a shield with which the caterpillar is said to close the hole it makes in the rind of the fruit. When full fed, the caterpillar comes out of the fruit and webs silk over the base of the fruit and some part of the stalk; it then re-enters the fruit and turns to the chrysalis. Apparently the webbing over the stalk is to prevent the fruit from falling to the ground; the behaviour of the caterpillar in anticipating this is an extraordinary instance of instinct, which almost amounts

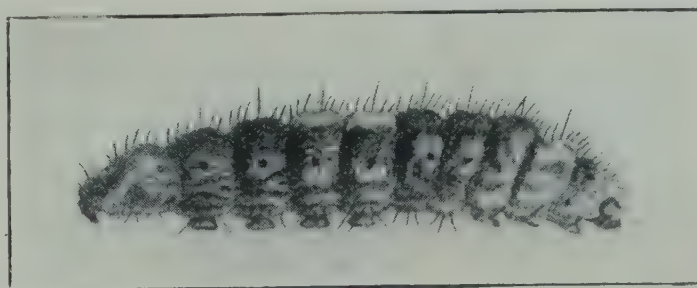

FIG. 200.
Anar Caterpillar. (Magnified twice.)

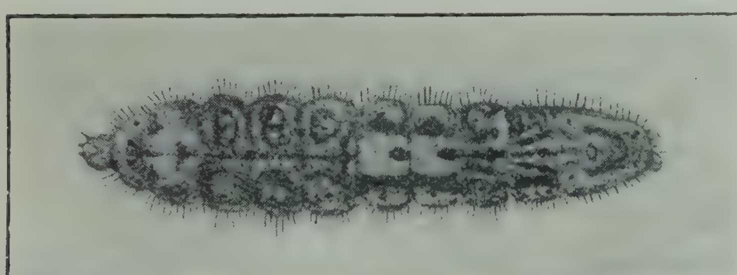

FIG. 201.
Anar Caterpillar. (Magnified twice.)

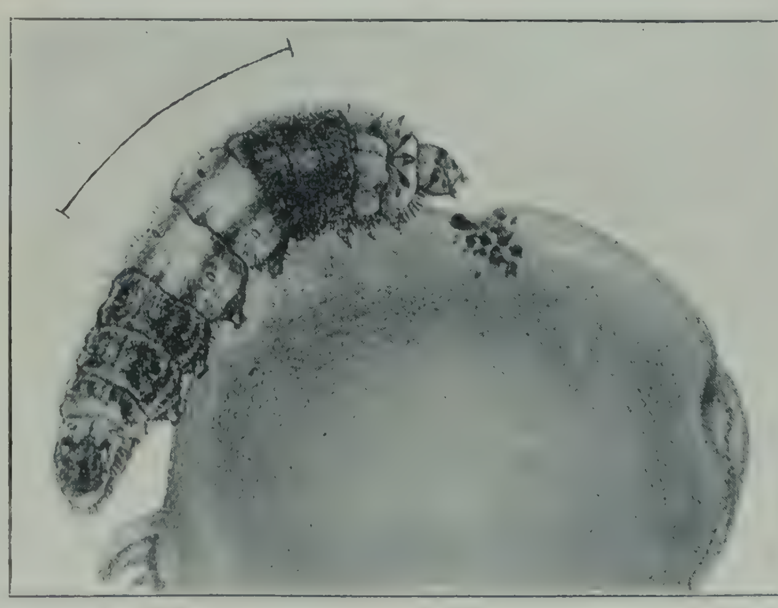

FIG. 202.
The Anar Caterpillar. (Enlarged.)

[1] 95. *Virachola isocrates.* Fabr. (Lycænidæ.)

to "reasoning." From the chrysalis a pretty butterfly emerges, which is found commonly in the cold weather.

Though feeding generally in pomegranates, the larva is also recorded from guava, loquat and wild fruits. It is distinctly a pest in pomegranate gardens and is a difficult insect to check. If all flowers came out together, it might be possible to systematically hunt the butterflies in the garden with nets. Though familiar with the caterpillars, pomegranate cultivators do not know the butterfly which alone can be checked. Nothing can save a fruit once attacked and only tying the flowers up in bags immediately after pollination could protect them from the butterfly. On the other hand, every attacked fruit should be burnt, simply to lessen the increase of the pest. This would not save the present crop but would diminish the pest for the next crop.

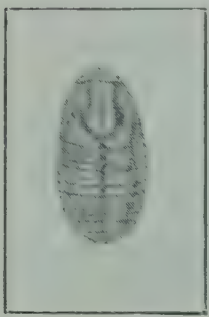

FIG. 203.
Pupa of Anar Butterfly.

FIG. 204.
Anar Butterfly.

FIG. 205.
Anar Butterfly, from above, in resting position.

FIG. 206.
Anar Butterfly.

CHAPTER XV.

CATERPILLAR PESTS.

CATERPILLARS are the young of butterflies and moths, recognisable as a rule by their sucker-feet. Nearly all are herbivorous, and as their rate of multiplication may under favourable circumstances be very large, they are common pests. In many cases the species that attack crops one season may next season be so few as not to be seen and other species may take their place; those that are specific pests of particular crops come every season, but these are dealt with above. It is impossible to say that a particular species attacks a particular plant in very many cases, as they vary much from year to year and may come out only at long intervals into the crops. Fortunately their habits are on the whole sufficiently similar to make certain general remedies suitable for all the caterpillars of a group, whatever their species. It is only necessary to consider their habits and not treat a leaf-eating caterpillar in the same manner as a surface caterpillar.

Leaf-eating Caterpillars.

Almost every plant that is cultivated as a field or garden crop is at

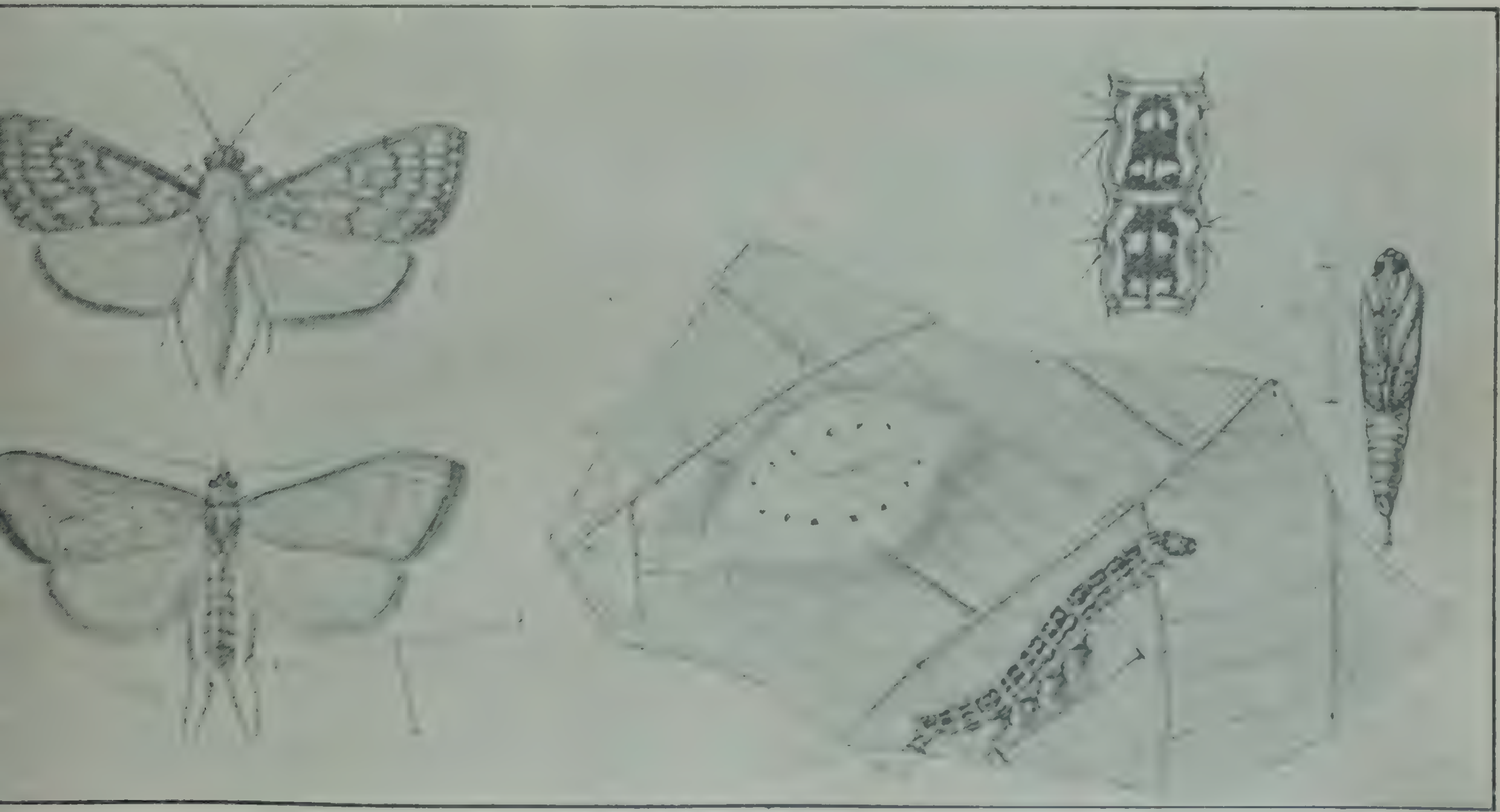

FIG. 207.
Leaf-eating Caterpillar common in the plains on teak. A similar species attacks maize.

some time infested with caterpillars which eat the leaves. This is the most common way in which herbivorous insects feed; a very large number of caterpillars are confined only to wild plants, whilst a smaller,

FIG. 208.
Hairy leaf-eating Caterpillar and its Pupa.

though still large, number have been found upon cultivated plants in the plains of India.

In most cases a few caterpillars are found on the plant, not sufficient to do any injury and often doing some ultimate good by effecting a simple pruning and manuring which stimulates increased production of flowers and seed. If the caterpillars increase or continue to infest the plants for a prolonged period, they cause an appreciable or total loss of the crop.

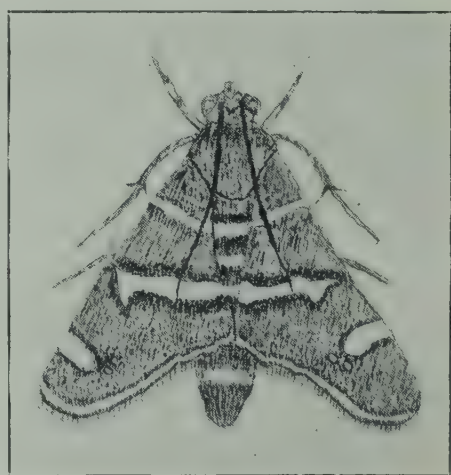

FIG. 209.
Moth of common vegetable Caterpillar. Wings in repose. (Magnified three times.)

Caterpillars of this kind are so common that they are often neglected until they multiply to such an extent as to do serious injury; they cannot then be checked by the simple measures that would have been successful if adopted in good time.

Leaf-eating caterpillars destroy the tissue of the leaves; if few in number they eat holes in the leaves; these holes or the little grains of

excrement being the only signs of their presence. Such grains of excrement are often mistaken for eggs, though caterpillars are unable to lay eggs.

FIG. 210.
Moth of common vegetable-eating Caterpillar. (Magnified three times.)

The life history of these insects is simple and can be easily traced in captivity. As a rule the parent moth or butterfly deposits a large number of eggs on the leaves of the plants, often on the under-surface, singly or in clusters, but usually spread over several plants. The eggs are small and not noticed as they are difficult to see. In the butterflies and larger moths each egg is rounded, a little flattened at the base and apex, adorned with sculptured lines and ribs. In the smaller moths, the eggs are commonly flattened, oval in outline and very inconspicuous. The eggs hatch in a short time, usually less than a week, into little caterpillars that crawl about on the plants and feed first upon the epidermis of the leaves.

FIG. 211.
Moth of common leaf-eating Caterpillar of rice.

When grown larger they eat holes in the leaves or eat in from the edge until the whole leaf is devoured. They are voracious, a large amount of plant tissue being consumed which is only very slightly digested and passes out of the body as a little round grain of excrement. Actually the greater part of the food consumed passes through, little more than the juice of the plant being absorbed by the alimentary canal.

FIG. 212.
Pupa and moth of Caterpillar that eats lilies.

The first moult takes place in a few days after hatching and successive moults occur until the caterpillar is full grown. Few of such

caterpillars grow to more than one inch long, many species never exceeding half an inch in length. When the body is not hairy but somewhat transparent, the caterpillars are often greenish from the colour of the food in the alimentary canal; or they are opaque green, brown, or variously striped and marked. Many are hairy, spiny and provided with horns and excrescences.

The duration of larval life varies with the different species: some are full fed in a week, others only after two to three weeks or longer. From two to three weeks is the most general length of the larval life. These caterpillars have regular daily habits which must be considered in the adoption of remedies; many feed only in the morning and evening, hiding away in the soil during the middle of the day; others feed principally at night or are to be found on the plant only in the early morning and late evening.

If food is plentiful they feed regularly and voraciously until they are full grown, when they turn to chrysalides. Before doing this they hide away, some making cocoons on the plant or in the soil, others entering the soil and making cells there, others again twisting over the leaf and thus making themselves a shelter. Butterfly caterpillars hang themselves to the plant or bend over a part of the leaf.

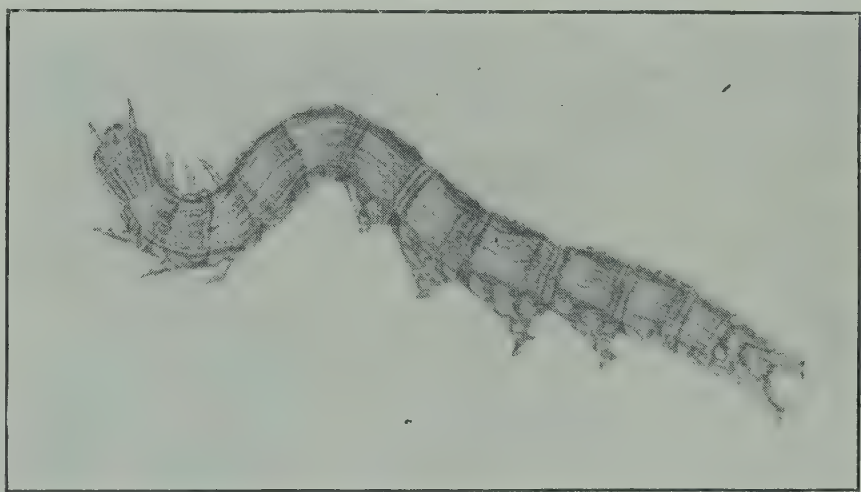

FIG. 213.
A Semi-looper Caterpillar, the first pair of sucker-feet reduced.

The period of pupation is determined by climatic conditions, and may be short, as in the rains, or prolonged through the cold weather and succeeding dry hot months until the next rains. Hibernation is the rule, and whilst some emerge as moths or butterflies at the close of the cold weather, the majority emerge only in the rains. The first brood appearing in April would be followed perhaps by a second in June, a third in August and the last in October; more usually there would be a

brood in July, another in September and then hibernation. Such general statements can only be accepted very cautiously as the habits vary with individual species.

It is not possible to give a list of the species which attack individual crops and such a list would serve no useful purpose. A detailed account has been given of several species (pages 96, 159, etc.). Rice is the food of many species, which are also grass feeders; the large area under rice usually allows for a large number of such caterpillars being widely spread so that the damage is distributed, but exceptionally they are so abundant as to cause serious injury. Some crops are apparently not attacked by caterpillars, such as the various yams (*Dioscorea* and *Colocasia*), and the tapioca (*Manihot*). Leaf-eating caterpillars are destructive principally in small areas of irrigated crops or in patches of special crops not generally grown in the district. The fields of mixed crops, grown to a limited extent in April, May and June, usually with well irrigation, suffer heavily from this pest, as many moths emerge from hibernation at this time and lay eggs on a small area of crop. Later in the year the same caterpillars may be spread over a far larger area of staple crops with no appreciable harm. The same may be said of special crops of which only a small area is grown; this applies particularly to experimental farms and is one of the reasons why crops grown on experimental farms suffer to so large an extent from insect pests.

In general, each species of caterpillar feeds only on a few closely related plants; thus there are species which feed only on cotton, bhindi, ambadi (*Hibiscus cannabinus*) and *hibiscus*, others on maize and sorghum or on cabbage, rape and mustard. A small number have a greater range of food-plants, such as the omnivorous Gram Caterpillar (page 144) which eats gram, opium, tobacco, tipari, tomato, maize, etc. It may be remembered that the caterpillars have no choice of food-plant in most cases, since they can move over only short distances, but the moths seek out the right plant on which to lay their eggs, their instinct telling them on which plants their young will be able to feed. If no plants are found the moths can live for a considerable period before laying eggs.

Treatment.—There are several simple methods of checking leaf-eating caterpillars and of preventing them from becoming serious pests. The simplest method is to pick them off by hand; it is of course useless then to liberate them near the field from which they were taken as the cultivator sometimes does, but they must be destroyed. In most cases the destruction of the first brood prevents the injury caused by the otherwise large second brood; unfortunately the first brood commonly

escapes notice as it is a small one and the large second brood is so abundant that hand-picking becomes a difficult business.

In some instances it is possible to shake the caterpillars to the ground and crush them. When the caterpillars hide in the ground by day-light, cultivation between the plants exposes them to birds and kills many. The same is true when they have entered the ground and become chrysalides. This is always necessary when the field is badly attacked, as a large number of chrysalides will probably be found there.

On low crops the use of the bag (page 72) is advisable, large numbers being swept up. As a preventive measure one must do everything possible to stimulate the rapid and healthy growth of the plant ; a strong vigorous plant that is putting out many leaves can stand far more than a weak unhealthy one.

The practice of sowing mixed crops has an influence on leaf-eating caterpillars and the mixtures sown especially on small irrigated areas in the dry hot weather are almost necessary if the main crop is to be established. The caterpillars which are very prevalent in these crops, attack a subsidiary crop which can be rooted out, leaving the main crop well established and healthy. Occasionally it is possible to use another crop as a trap for caterpillars, which then do not injure the main crop. Thus sorghum and maize are valuable in certain areas in cane fields and the value of bhindi as a trap for pests of cotton is being tested. Such plants must be used with caution. If allowed to grow too long they first attract pests from outside and then transmit them to the main crop, becoming breeding places for undesirable insects which when abundant leave them. The essence of a trap crop is to destroy it with the insects on it at the right moment. Birds are extremely valuable as checks on leaf-eating caterpillars and anything which encourages such caterpillar-eating birds as mynas is useful. The growing of roadside trees has a very special value in this connection, especially when these trees are such as mynas frequent, and the cultivator's practice of putting branches of trees in an infested field of paddy so that the insect-hunting birds may come and perch there is a shrewd one. The common hen is a valuable ally in gardens and small cultivation, but she requires some food besides caterpillars and must not be left to feed exclusively upon them.

In most cases one of the above precautions can be applied successfully and when all else fails, an application of insecticide can be resorted to if the crop is worth it. For small areas of vegetable crop and for small irrigated patches, the tin sprayer and a dose of kerosene emulsion does all that is required ; if the caterpillars are large, lead arseniate may be

advisable, either sprayed or dusted on. In some cases a mixture of dry dust and kerosene or dry dust (or lime) and sanitary fluid can be applied to the plants; this acts with plants like cabbage, maize, sorghum, etc., whose leaves are so formed as to hold the powder. Every attack of leaf-eating caterpillars can be so checked, but the cultivator will not always think the crop is worth the cost of the insecticide or the labour. The application of insecticides by means of tin sprayers is more readily adopted by market gardeners who grow vegetables for sale in the towns, than by cultivators; every cabbage that is eaten by caterpillars means a loss to the market gardener.

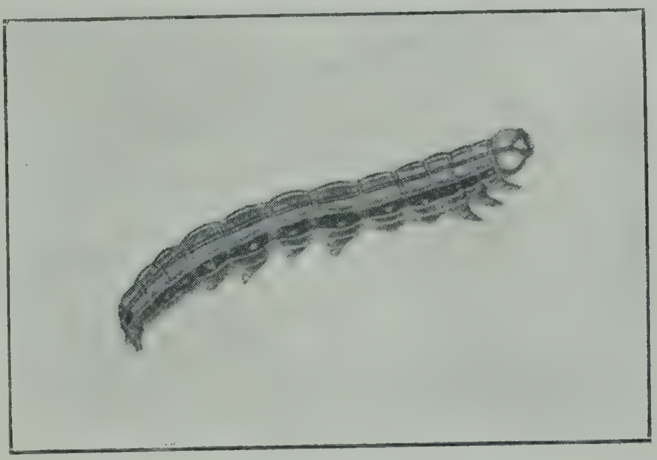

FIG. 214.
Typical Swarming Caterpillar.

At present over thirty species of leaf caterpillars are known which attack crops. Many more species will be found, but all have essentially the same habits and life history.

The question of parasites is a very important one in connection with leaf-eating caterpillars. As a rule when these caterpillars become very abundant, the parasites also increase to such an extent as to kill a very large percentage of the pupæ. The result is that few moths hatch and the pest does not reappear as it otherwise would. This is discussed in a later section (page 268).

Swarming Caterpillars.

It is not unusual to find that large numbers of caterpillars come out suddenly in the fields, ravage the crops and disappear. The caterpillars are large, smooth, not hairy, coloured in green or brown usually with stripes along the body from head to tail. They appear in large numbers, eat a variety of crops, and disappear.

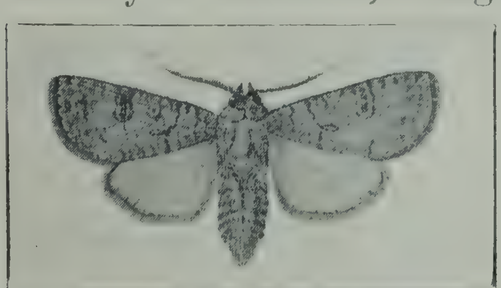

FIG. 215.
Moth of Swarming Caterpillar.

This form of pest is very similar to the last but is distinct in that the caterpillars really appear in swarms, and damage large areas of crops. The methods of treating such an attack are not the same as those used against the ordinary leaf-eating caterpillars.

In every case of swarming caterpillars, the following is the sequence of events that occurs. Under favourable circumstances a large number of moths hatch at a particular time; very many emerge from the chrysalides simultaneously and may be seen flying about in the evening. These moths lay eggs; every female moth lays at least a hundred and some lay as many as one thousand; if circumstances are favourable they all lay eggs within a few days. After a week or so, the eggs hatch out and multitudes of caterpillars appear. They are very tiny at first and feed steadily; if plentiful they devour the plant they hatch on, becoming perhaps half grown; they then commence to search for food and wander about; if large numbers are hatched out, they then form into masses and if they find a crop they will absolutely destroy it.

When they have become full fed they descend into the ground and become chrysalides, forming for themselves earthen cases in the ground. All will perhaps disappear in a few days and the reports say that they have died; but should circumstances be favourable these chrysalides will yield moths which will again lay eggs, giving rise to a fresh attack.

FIG. 216.
Moth of a common Swarming Caterpillar.

Such is the usual sequence; since the cultivator only sees the caterpillars feeding, he does not understand the cause, nor does he connect together the appearance of moths and the subsequent swarms of caterpillars. These attacks are worst when the conditions are such that the moths all emerge from the chrysalides together. At the end of the cold weather it becomes warm perhaps within a very few days; then a vast number of moths hatch out together; should the cold weather end early the caterpillars attack the rabi crops, and the destruction may be very large; if the cold weather continues later the caterpillars may not find crops to eat; if it comes very gradually, the moths do not all hatch out at once and the caterpillars do not come in swarms. If the caterpillars do not come in swarms the wild plants may be sufficient for their food and the crop will possibly not be attacked. Swarming caterpillars are worst when they are so abundant at one time that they exhaust their wild food-plants and are compelled to enter the crops to find food.

These caterpillars do not occur throughout India; they are serious pests only when the conditions are favourable and such conditions are not universal in the plains of India. The climatic conditions of Behar and the United Provinces seem to be particularly favourable to them, possibly because the cold weather suddenly gives place to the warm weather when the moths hatch out in abundance. Little is yet known of the occurrence of such swarms of caterpillars but they are likely to occur wherever the conditions favour them.

A curious feature of these caterpillar swarms is the number of species that are found composing them. Apparently the favourable conditions that produce a large number of one species favour others and we find several species, one in great numbers, others in smaller but still, in the aggregate, large numbers. For this reason also, it is impossible to rely upon the reports and specimens sent in, and as only a few cases have been investigated, little is known of the species which occur in this way. The basis of a swarm is nearly always a caterpillar of the kind known as an "Army Worm," that is a smooth-striped caterpillar (fig. 214), which emerges into one of perhaps six moths[1] of the type figured. With them are for instance the Tobacco Caterpillar (fig. 176), the Sorghum Caterpillar (fig. 156), the Gram Caterpillar (fig. 162), several butterfly and many other moth caterpillars which are typically leaf-eating caterpillars.

As these pests occur suddenly and not regularly, little has been done to check them or to test the best means of destroying them. The usual methods of applying lead arseniate would be the best if generally available; this should be done on experimental farms. Other methods depend upon the local conditions. The great thing is to do something quickly; the cultivator does nothing, because he thinks that caterpillars are sent as a punishment or at least have a miraculous origin.

When the crops are young or low the usual hopper bag can be used to sweep up the caterpillars (see page 72); discretion must be used in doing this only when the caterpillars are out feeding. When this is not possible, an application of lime and kerosene, road dust and kerosene or other offensive powders may be of use. When the caterpillars are concentrated in a small area, it may be possible to trench all round to isolate them, then apply a mixture or a spray or worry them with a hopper bag till they become restless and move, when they will fall into the trenches where they may be killed.

[1] 237. *Agrotis flammatra.* Schiff. (Noctuidæ.)
238. *Euxoa segetis.* Schiff.
235. *Spodoptera mauritia.* Boisd.
239. *Euxoa spinifera.* Hubn.
240. *Agrotis ypsilon.* Roth.
110. *Caradrina exigua.* Guen.

Trenching is one excellent method of isolating them, and so long as the trench has sloping sides, it need not be more than eight or ten inches deep. The cultivator naturally hopes the caterpillars will go into his neighbour's plot of land and does not trench to isolate them on his plot; his neighbours should trench to protect their own fields. Methods of surface cultivation are useful when the caterpillars bury themselves by day; light surface cultivation turns them out where the birds will eat them. So also when the caterpillars disappear; probably they have gone into the soil to pupate. Surface cultivation turns them out for the birds to kill them.

The principal reason why nothing is done to check these pests is that they invariably disappear after a time (to pupate and come again as moths). The cultivator hopes they will do no harm and sooner or later sees them vanish; he attributes this to invocations of holy men or to fate, but does not realise that they will come again and are not dead but undergoing metamorphosis; should circumstances be favourable, the increase of the emerging moths will be enormous.

These pests come from jungles and waste lands; the planting of waste lands; strips bounding on fields, boundary strips, etc., with good grass would do much to check them; trees are not liable to bring them but flowering plants and low vegetation encourage them. The ideal cultivated areas would include no waste lands with scrub where such vegetation is growing, but only grass land and trees.

Finally the most important thing is to worry the caterpillars and prevent them feeding. The bag, a rope, a *lathi*, almost anything dragged through an infested crop disturbs them. In a plague of swarming caterpillars recently investigated, it was found that sweeping the crop with a heavy *lathi* was sufficient to disturb the caterpillars so much that they stopped feeding. It was only necessary to do this twice a day and the crops were practically uninjured.[1] If it were possible to induce the cultivator to do anything energetically, no matter how simple, such plagues could be rendered almost harmless.

Surface Caterpillars.

Caterpillars, which hide by day in the soil and come out at night to eat vegetation or to cut off young plants, are commonly known by the above name, or in America as "cut-worms." They are large, smooth caterpillars coloured in dirty brown, green or neutral tints, with obscure longitudinal lines, or in some cases with black spots. When handled

[1] Report of C. S. Misra and D. N. Pal.

they curl up, not as a cockchafer grub does with the ventral surface inwards, but to one side.

These caterpillars are universal and some species are of almost world-wide distribution. It is scarcely known how many species behave in this way in India; though several common species have been reared, it is exceedingly difficult to determine accurately how much damage they do, and in recent years only one species [1] seems to have been common or abundant.

This is the so-called "Greasy Cut-Worm," and its life history may be taken as typical of the group.

The moth lays a very large number of small white eggs singly, on weeds or stones, in any convenient situation near the ground in waste lands, in grass borders, near fields or in weedy fields. The caterpillars feed on plants and live by day in hiding, coming out at night to feed. When half grown they have a habit of biting through the base of the plant, if it is a small one, thus cutting it off; the plant is then removed to the burrow in the soil where the caterpillar finds shelter. Night after night the caterpillar lives thus, until it becomes over an inch long, and is large enough to destroy half-grown opium plants. Each caterpillar cuts off more than it can eat and the destruction caused is very large. When full grown the caterpillar makes a cell in the ground pupating there. The moth emerges after a varying interval, and there is reason to believe that though the caterpillar remains active through the winter in most parts of the plants, the pupa hibernates in moderate cold.

Surface caterpillars feed principally upon weeds, in waste lands or unweeded fields. They are often abundant, not in the crops, but in weedy places where there is good growth of low vegetation. They attack crops principally after floods; the exact explanation of this fact is not understood, but it appears to be generally true that, when land has been flooded, cut-worms are found on it in the ensuing *rabi* season, and that after extensive floods, surface caterpillars are most abundant in fields and gardens. The number of surface caterpillars may also be influenced by the character of the season, damp weather being favourable to the emergence of moths and consequent rapid breeding. Surface caterpillars are found most abundantly on young *rabi* crops and throughout the cold weather. They attack a great variety of crops, including opium, tobacco, gram, peas, lucerne.

Surface caterpillars are not generally distinguished from leaf-eating caterpillars which never live on the surface or from the swarms of the caterpillars which come in March, April and May. Yet these surface

[1] 240. *Agrotis ypsilon*. Rott. (Noctuidæ.)

caterpillars need quite distinct treatment and cannot be checked by the same methods as other caterpillars.

The principal precaution against them lies in clean cultivation, which includes putting all waste lands, boundary strips, etc., in good grass; large areas of weeds and low vegetation promote cut-worms, affording a breeding place from which the caterpillars or moths come.

When the caterpillars attack a crop, heaps of any green vegetation should be placed in the field to attract them. This is not only necessary to supply them with some other food than the delicate young plants, but large numbers will be trapped in this way and can be collected daily and put into water.

The use of poisoned baits of bran or bhusa and arseniate is a remedy in use elsewhere; it will probably be found suitable and has given good results on an experimental scale of 5 acres (see page 287).

FIG. 217.
Hairy Caterpillar of Behar.

When the cultivators are familiar with the habits of the pest, they are able to destroy it by searching daily for the holes of the caterpillars, betrayed by the green leaves of the food taken in the night to the burrow. This is the simplest remedy and one that, energetically applied, averts a great loss in opium and tobacco crops.

When possible, irrigation brings up the caterpillars and in bad cases would clear the field; simply flooding the field once is sufficient to bring up all the caterpillars in the soil when they may be destroyed or they may be left to the mynas to eat. It is stated that the caterpillars, when on their nightly prowls in search of plants, can be trapped in smooth holes made in the soil with a pointed stick; the stick is rotated till a neat hole with smooth sides is produced; a caterpillar falling in cannot get out and is killed next day.

The outbreaks of surface caterpillars which take place after the cold weather are preceded by the emergence of the moths, a phenomenon at

once recognised by anyone familiar with the moths; the moths come to light and are found in houses at night. The species[1] figured (fig. 216) comes out in vast numbers, in February or March, flying in the dusk; other species do the same, and an observer familiar with the moths will recognise them and expect a later attack of caterpillars.

FIG. 218.
Moth of Behar Hairy Caterpillar.

Hairy Caterpillars.

In many parts of India, large numbers of hairy caterpillars appear at certain seasons and either destroy special crops or move from field to field attacking almost any crop. These pests appear when conditions are favourable to the emergence of large numbers of the parent moths which lay eggs on crops or on wild plants; if the eggs are abundant, the caterpillars ravage the crops or, after eating their wild food-plants, move into crops and devour them.

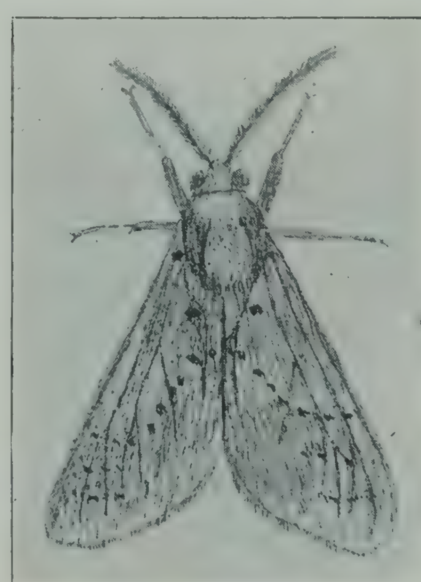

FIG. 219.
Moth of Behar Hairy Caterpillar.

Apparently particular species are destructive in distinct areas; the hairy caterpillars of Guzerat are distinct from those of Behar and Oudh, and from those found in Madras. Their time of appearance varies with climatic conditions, but is largely confined to the rains. In Guzerat, they appear chiefly in the early weeks of the rains; the moths hatch out in abundance with the first rains, lay eggs, and the caterpillars hatch and feed on the young crops. In Behar, one brood succeeds another from the end of the cold weather, and this will occur when the conditions are favourable. The life history

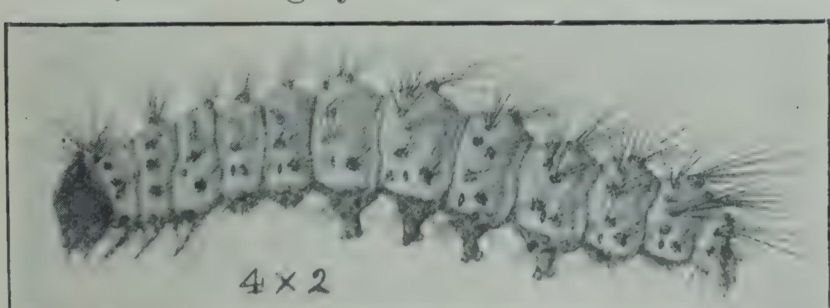

FIG. 220.
Jute Hairy Caterpillar. (Magnified twice.)

[1] *Agrotis flammatra* (Noctuidæ).

of these caterpillars is similar to that of the preceding caterpillars. The moths lay eggs in clusters on their food-plants, the eggs hatching in a few

FIG. 221.
Moth of Jute Hairy Caterpillar. (Magnified twice.)

days as a rule. The caterpillars feed for two to four weeks and become chrysalides in a cocoon in the ground or hidden away under stones, etc.; the moth emerges in five to ten days and again lays eggs. The whole period from egg to egg is four to six weeks, so that several broods succeed one another so long as conditions are favourable.

The caterpillars are very characteristic in appearance; they are long, usually of a black and yellow colour, with hairs covering the whole body. When the caterpillar pupates, the hairs are used with the silk to prepare the cocoon.

The moths are distinct in appearance from the moths of other injurious caterpillars; most are brightly coloured, red, orange or white with black markings, or dots.

Less than ten species[1] seem to be common in different parts of India, attacking a variety of

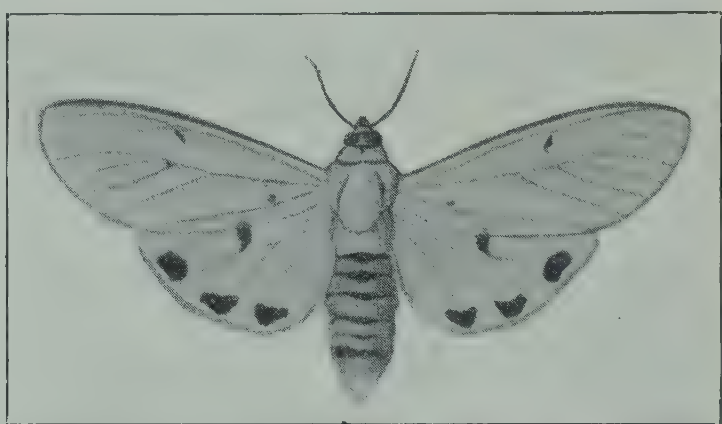

FIG. 222.
Moth of Gujarat Hairy Caterpillar.

[1] There are four principal species in India—
233. *Amsacta moorei.* W. Madras.
231. *Amsacta lineola.* F. } Gujarat.
220. *Amsacta lactinea.* Cr. } Gujarat.
136. *Diacrisia obliqua.* Wlk. Behar and Oudh.

plants. Groundnut and sann hemp are the usual food-plants, but when the caterpillars are abundant, they will attack indigo, castor, til, cotton, jute, tobacco and other crops. The methods of treatment are similar to those used against the usual leaf-eating caterpillars. In case of a small attack the brightly coloured caterpillars can be readily seen and picked off. This is of great importance in the case of the first brood as by destroying that, much subsequent loss may be saved.

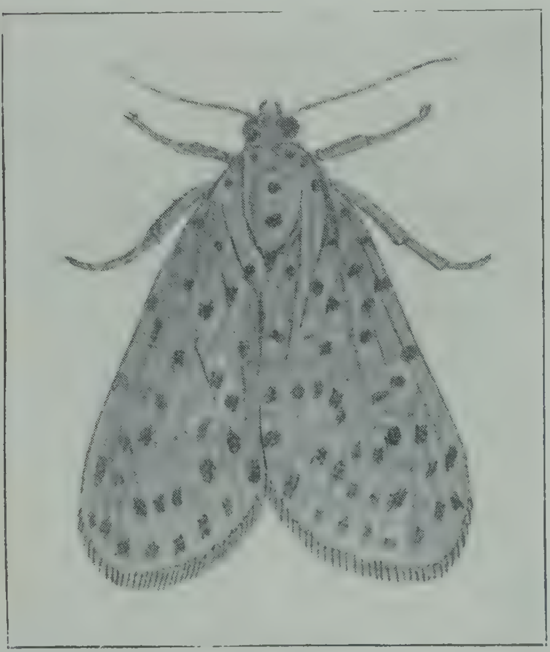

FIG. 223.
Orange Sann Moth.

As the caterpillars become chrysalides near the surface of the ground, light cultivation does good, if carried out when the caterpillars disappear from the plants. In this and in other cases of caterpillar attacks, much depends upon what weeds are growing near the fields; if certain leguminous weeds grow in the jungle or in the waste lands near the fields, the moths are likely to be present and to lay eggs on them; should the caterpillars be abundant, they will enter the crops after eating the weeds (see also page 192).

The radical treatment is, as in other cases, to apply a poison such as lead arseniate, dusting or spraying it on the plants in powder mixed with lime or dust. As these caterpillars occur chiefly upon field crops, this method is as yet beyond the reach of the cultivator. It is far better to anticipate the caterpillars and collect them on their wild food-plants before they attack the crops; they appear as a rule only at definite times, and a search through any lands growing weeds will probably reveal them and show what their wild food-plants are. The caterpillars must then be collected and destroyed; in places where such caterpillars come often, a watch should be kept particularly for the first brood which must be destroyed on its wild food-plants before it attacks the crops.

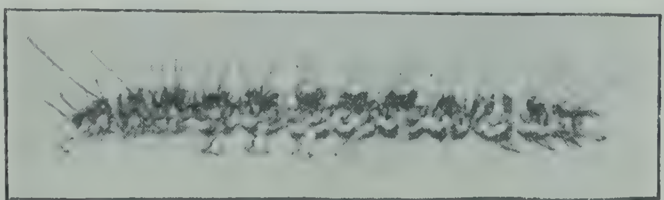

FIG. 224.
Hairy Caterpillar from Sann Hemp.

CHAPTER XVI.

BEETLE PESTS.

BEETLES form the largest and most varied group of insects including many distinctive species. As they live concealed, their larvæ are so seldom found that far less is known of them than, for instance, of caterpillars. They are also far more difficult to distinguish specifically. It is, therefore, necessary to discuss groups rather than individual species. Increased knowledge will show that beetles are far more destructive than is generally known; especially will this be so in the "weevils" whose larvæ are almost wholly herbivorous but live lives of such concealment that we are still ignorant of the life histories of our commonest species. Beetle grubs are notoriously hard to rear and cannot be identified until they are reared. Any observer who is so fortunate as to rear one should put the facts on record, for such inquiry is most needed.

Cockchafer Beetles.

These beetles appear in large numbers at regular seasons of the year, flying by night and feeding upon leaves. They are round, thickset insects, usually hard, not more than half an inch long, and most easily recognised by the peculiar knob at the end of the antennæ (see fig. 225). Their colour is generally brown, black or some sombre tint, but some are very bright metallic green, others a vivid red brown with white spots. All have the same build, the same antennæ and the same heavy droning flight.

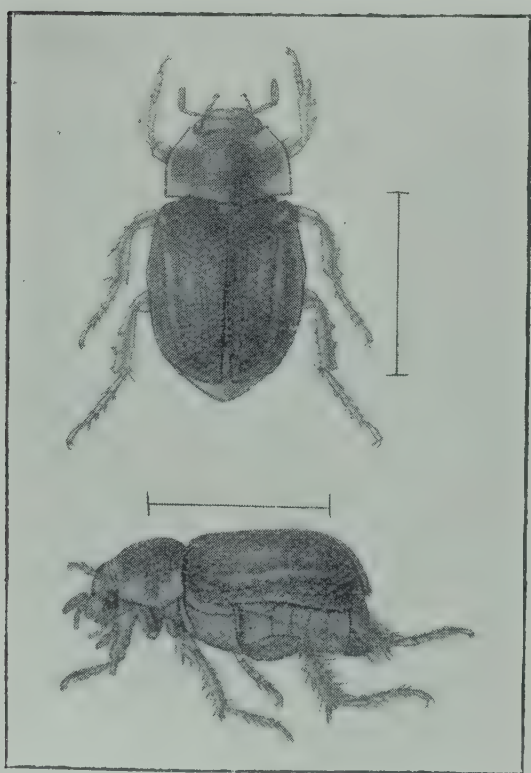

FIG. 225.
Cockchafer Beetle.

Cockchafers are not often reported as injurious insects, but do far more harm than is generally known. They are destructive at two periods in their life—below ground as the larva, above ground as the imago. The larva is a white grub, with large brown head, a much wrinkled white body curved in a half circle and

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three pairs of legs. It may be found almost anywhere by digging in the soil, and the larger specimens have a peculiarly large terminal segment of a livid grey colour. This grub lives among the roots of plants, a few inches below the surface of the soil. Its food is probably entirely vegetable, consisting of the roots of grasses and other plants; hot dry weather sends the grubs down further from the surface, wet weather brings them up. The life occupies several months, probably nearly nine; the full-fed grub makes a smooth earthen case, curls up inside and transforms to the pupa. Nearly a year after the parent laid the eggs, the beetle comes out, pushing open the mud case, forcing its way up through the soil till it emerges to the light. It distends the air sacs in the body and flies away. Each species emerges annually at the proper season depending upon the climate, so that we find large numbers of a species coming out about the same time. They lie hidden in the day and in the evening fly out, to seek a suitable plant on which to feed. On such plants they gather in numbers, eating the tissue of the leaves till the whole plant is stripped, only the skeleton of the leaf being left. The beetles mate, and lay eggs in the soil, after which they die. The whole period may occupy one year or more and probably one or two years are required by most Indian species.

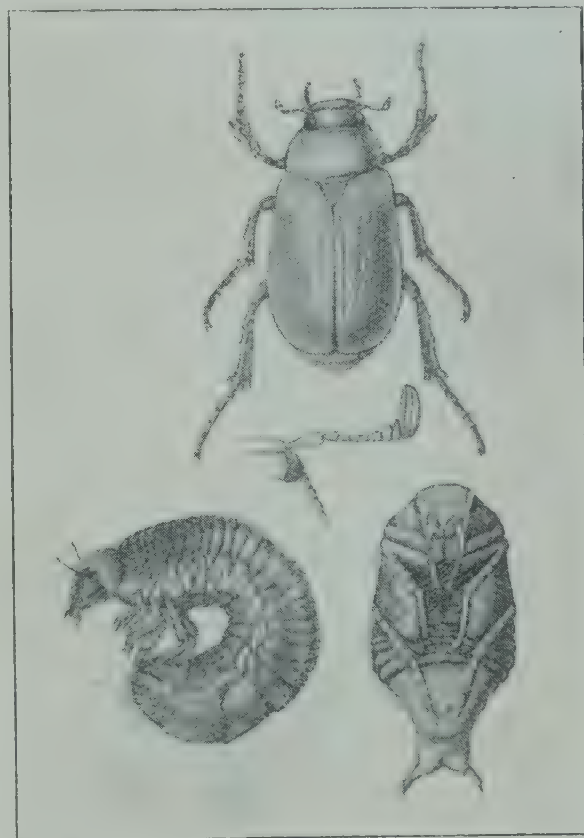

FIG. 226.
Cockchafer Beetle.
Larva on the left. Pupa on the right.

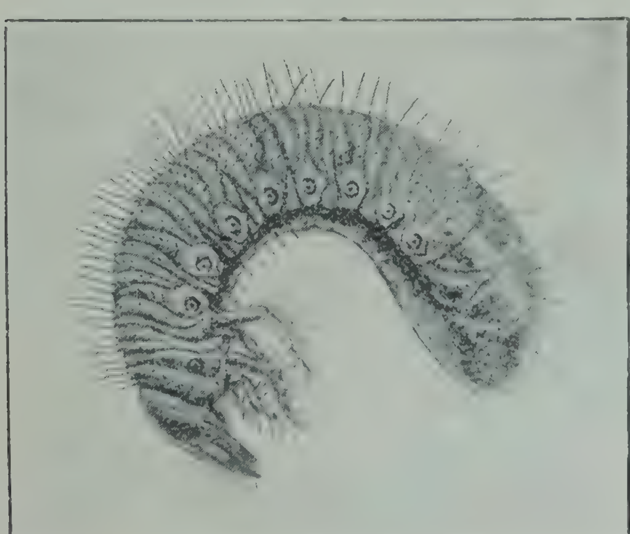

FIG. 227.
Cockchafer larva. (*Twice magnified.*)

Damage is done by the larvæ to the roots of plants, especially in very wet weather when the grubs come up near the surface. Crops are occasionally

attacked, bajra (*Pennisetum typhoideum*) and other millets especially; there are also many cases of injury to garden plants and vegetable crops, the grubs living for choice in highly manured soil. Nurseries and especially manured plots are usually full of the grubs, which may hatch from eggs laid there by the beetles, or may be put in with the manure if farmyard manure is used.

FIG. 228.
Cockchafer larva.

These grubs are difficult to destroy; where it is possible, cultivation turns them out when birds then eat them readily; flooding brings them up nearer the surface where they can be more readily turned out but never actually kills them or exposes them. In hot weather, anything that tends to dry and heat the surface soil drives the grubs down below the surface roots. Artificial manure such as kainit, saltpetre, etc., can sometimes be used sparingly to drive them down and a dressing of soot has much the same effect. This is the only thing possible when grass lawns are affected, though a liberal watering with soapy water may do good.

FIG. 229.
Cockchafer larva, found in the soil.

The beetles destroy plants in a more evident manner, coming out at night in large numbers and stripping the plants. This is somewhat

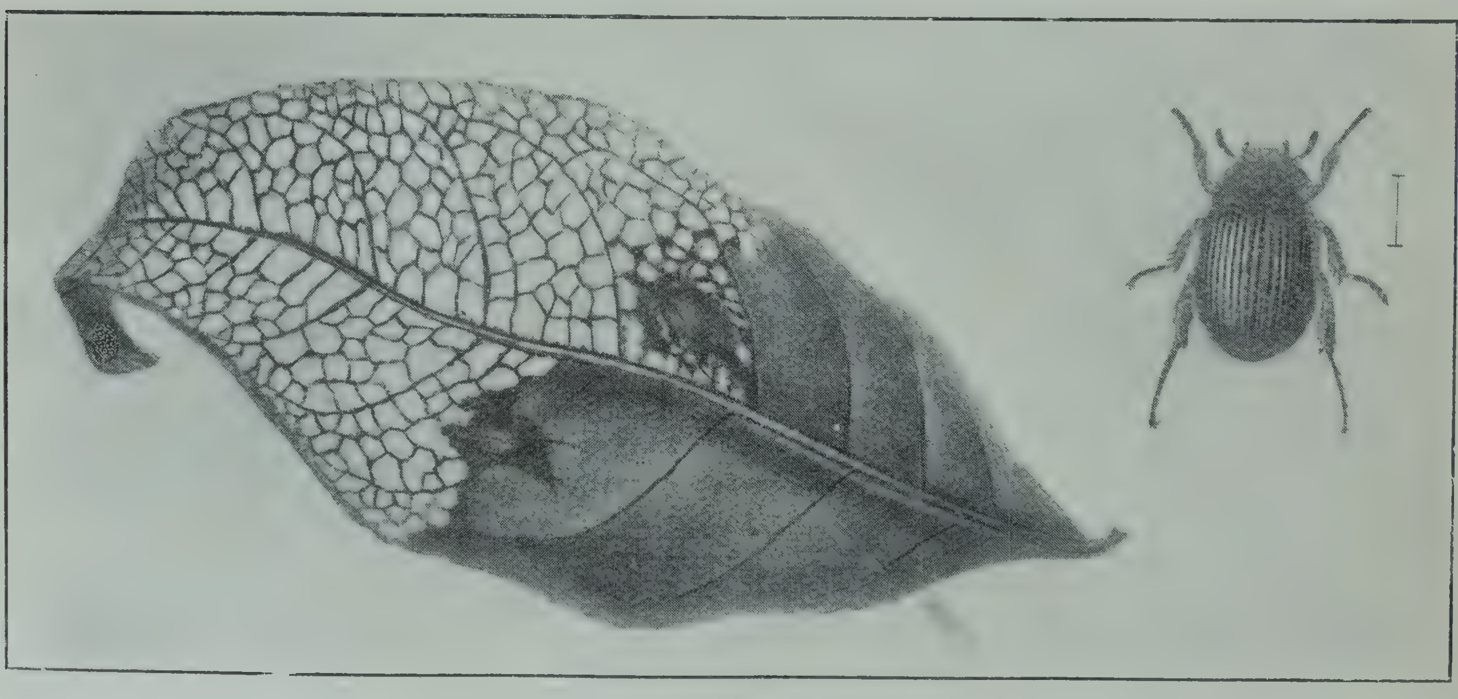

FIG. 230.
Cockchafer Beetles eating a leaf.

rare in the plains but more common in the hills, where the beetles are more abundant. Cockchafers thrive best in the long open stretches of grass land, and though found throughout the plains, rarely come in large numbers. The time of emergence depends upon climatic conditions and is usually regular. A species that emerges at the commencement of the rains does so always, whatever the date of the rains. It is accordingly possible to expect these insects at regular seasons, as at the beginning of the rains, and to take measures accordingly. In fruit gardens, certain plants are especially attacked and these must be protected. Only experience can tell which plant will be attacked in any locality as the species have differing habits. As a rule it is useless to spray plants with lead arseniate, as the beetles feed and poison themselves but still strip the plants. Spraying with weak contact poison is better as it makes the plants distasteful but the effect does not last. The best and only real method is to use the light trap, an arrangement of a lantern, two reflectors and a pan of jaggery or kerosene and water. Where measures are required on a larger scale, fires are useful. Fortunately the beetles do not fly for many nights and fires are not required for long; this is practically the only method of protecting crops.

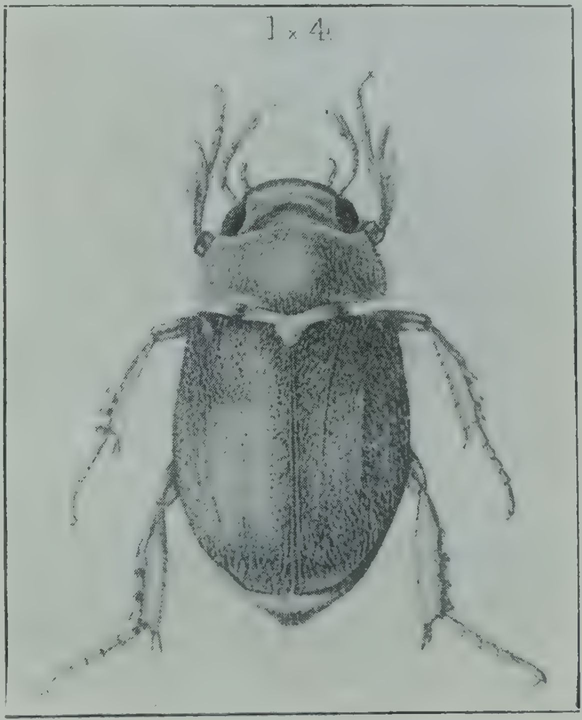

FIG. 231.
A Cockchafer Beetle.
(Magnified four times.)

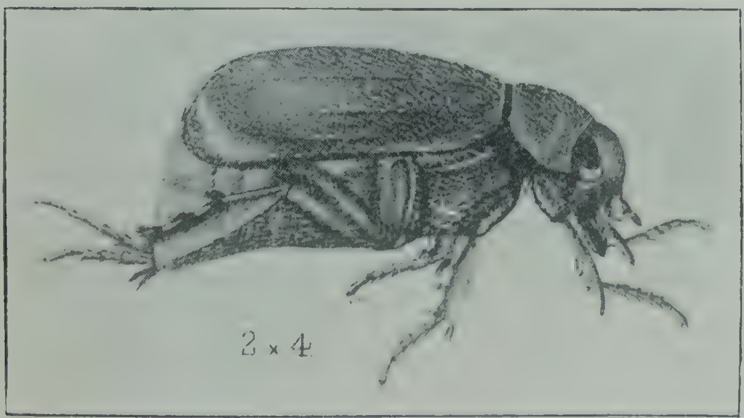

FIG. 232.
A Cockchafer Beetle. (Magnified four times.)

Cultivation of waste lands, together with proper cultivation of arable land, are radical cures for such pests. The occurrence of cockchafers in destructive numbers depends largely upon the extent of uncultivated land and may be looked for in perhaps every other season in places where the conditions for increase are suitable. Where the soil is ploughed or deeply cultivated

only once a year and this coincides with the time of flight of the beetles, the larvæ and pupæ remain undisturbed in the soil for the whole of their lives and are never turned out for the birds to eat.

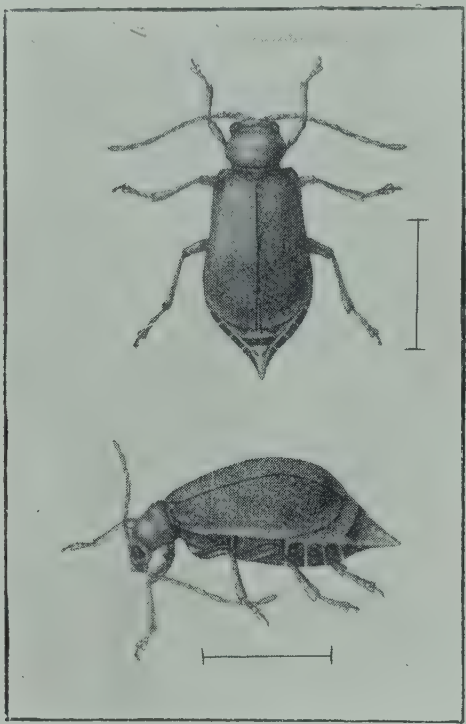

Fig. 233.
Red Pumpkin Beetle. (*Magnified.*)

A special form of injury to the crops occurs when the ripening period of the millets coincides with the period of emergence of cockchafers; the latter then feed upon the soft grain, settling on the ears of bajri or other millets at night. The attack lasts for a short time but is very serious, the actual grain being destroyed in a wholesale manner. This form of injury is not uncommon in the plains. Very little can be done to check such attacks; fires of green stuff should be lit round the fields, and the beetles should be disturbed by dragging a rope or long cloth through the field so as to brush the ears. The essential thing is to disturb the beetles as they will not live long and, if they are prevented from feeding for a few nights, the grain will be secure.

Another special form of injury to flowering plants in the hills is caused by very small cockchafers, which emerge from the soil in vast numbers and feed on white flowers such as roses, spiræas, etc. These feed by day and are attracted to anything white, or light coloured. They can be trapped on a white sheet or by hanging up a white cloth over a large pan of kerosene and water; the beetles that collect must be periodically gathered or shaken into the pan.

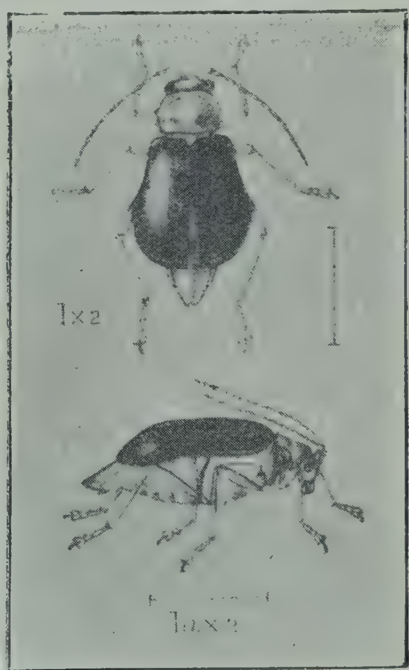

Fig. 234.
Black Pumpkin Beetle.
(*Magnified.*)

Leaf-eating Beetles.

A large class of *Coleoptera* feed upon the leaves of plants in a manner similar to caterpillars. These beetles eat the tissues of leaves, either making holes in them or completely stripping the plants. The greater number feed upon wild plants, specially in the hills. A few have become pests in the plains and are abundant in the crops.

The life histories of these insects are for the most part unknown. The beetles alone do harm to plants and it is not yet known where they lay eggs or where the larvæ feed. The Rice Hispa is an exception, its life history being described separately (page 114). There are a few well marked and fairly common species which may be recognized by almost any one from the figures given here, and there are a number of others which are likely to be found more rarely in particular localities. The Red Pumpkin Beetle[1] is an orange red beetle, not more than one quarter of an inch in length, which is found commonly attacking melons, gourds, cucumbers, and other cucurbitaceous plants. It is not limited to these plants, but is a common pest in gardens and in small patches of irrigated lands. The ordinary field crops are rarely attacked.

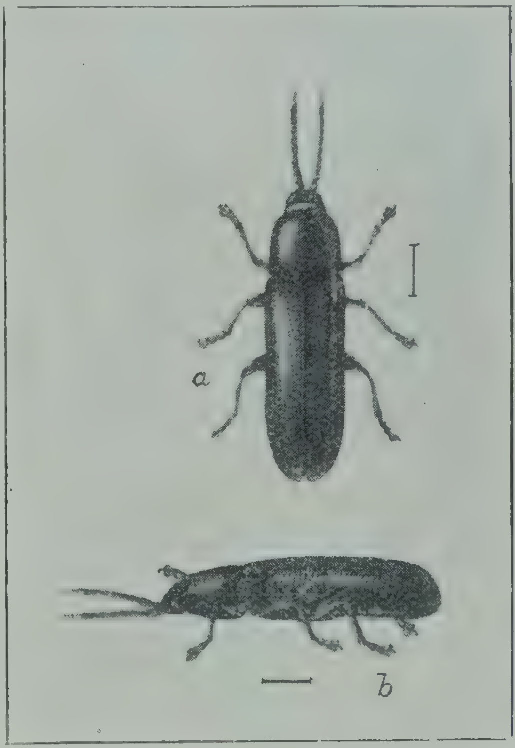

FIG. 235.
The Rice Leptispa. (Magnified.)

FIG. 236.
A Tortoise Beetle; eggs (lower left figure); larva (middle row); pupa (upper right and middle) and beetle.

[1] 11. *Aulacophora foveicollis.* Küst. (Chrysomelidæ.)

With it is a very similar beetle[1] differing only in having the wing covers black instead of orange.

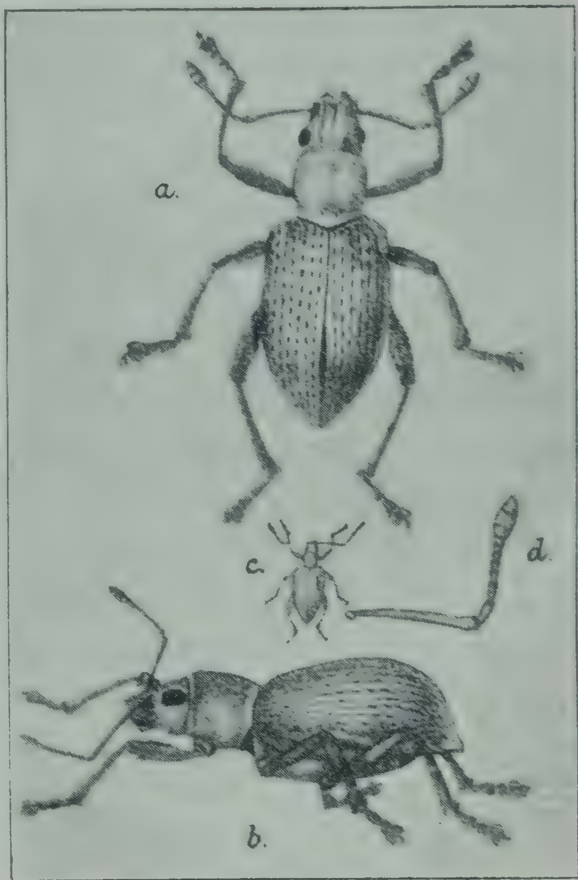

FIG. 237.
The White Weevil. (Magnified and natural size.)

A smaller blue beetle[2] (fig. 235), very flat, with parallel sides and no spines, is found on the rice with the Rice Hispa, and is also found upon sugarcane. The life history is not known, but is probably similar to that of the Rice Hispa, to which it is closely related. Sweet potatoes are infested by a small golden tortoise beetle (fig. 236), whose flat green grubs feed on the leaf and carry their excrement over their backs on a special moveable process. The whole life history is passed on this plant as on other *Convolvulaceæ,* but the insects are rarely abundant and do no harm. The White Weevil is a small beetle[3] with the head produced in front into a short beak (fig. 237); it feeds upon cotton leaves principally and is commonly found upon the plant. If the plant is shaken the weevils fall to the ground and lie motionless, shamming death. If it were a pest, this habit could be made use of to destroy the beetle, but no case is yet on record of this insect being sufficiently abundant to cause harm.

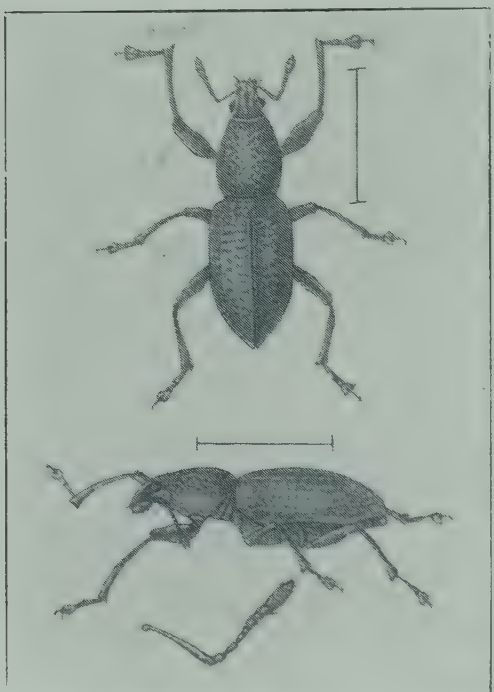

FIG. 238.
Green Weevil. (Magnified.)

A similar but larger beetle[4] is common on indigo; it has a glistening green appearance, is larger than the White Weevil and is sometimes found with it on cotton (fig. 238). A few other weevils have been recorded as feeding upon different plants; such weevils are common among wild plants, and are rarely found upon cultivated plants. The simplest treatment

[1] 125. *Aulacophora excavata.* Baly. (Chrysomelidæ.)
[2] 124. *Leptispa pygmæa.* Baly. (Chrysomelidæ.)
[3] 6. *Myllocerus maculosus* des B. (Curculionidæ.)
[4] 188. *Astycus lateralis.* Fabr. (Curculionidæ.)

is to shake them off into an open inverted umbrella or a kerosene tin; where they persistently attack valuable plants in gardens, a dose of lead arseniate sprayed upon the plants is sufficient to kill them. The ordinary simple butterfly net is a handy weapon against all such beetles; it is described in the appendix and a few boys with nets can work havoc among beetles on garden plants.

Flea Beetles.

Fleas are those small active insects which infest human beings and domestic animals, and are characterised by great leaping powers.

Flea beetles have similar leaping powers, are nearly as small but live on the leaves of plants. They are very small insects, usually less than one-eighth of an inch long with the shining appearance of the usual beetle and coloured steel-blue or brown. They bite small holes in the leaves they infest, giving a very characteristic spotted effect which is quite clearly recognisable. The spotted leaves betray them, and a plant with such leaves is almost sure to be infested even if the beetles cannot at first sight be seen. These active beetles are difficult to catch.

FIG. 239.
Rice Flea Beetle. (Magnified.) On the right the hind leg to show the immense thigh that characterises these beetles.

The life history of no flea beetle has been worked out in India. In general their larvæ are leaf-miners tunneling in the tissue of the leaf between the upper and lower epidermis. The larva thus lives inside the plant, the imago outside. Others are miners in the stem or some other portion of the plants. These mines are seen as lines or blotches on the leaf, but as they are produced by many other insects beside flea beetle larvæ, care must be taken in rearing them.

Few species are destructive in India and little is known about them. They are found as occasional pests, but not doing injury to important crops. One species attacks wheat and is common on irrigated wheat plots in experiment farms. Another attacks mustard crops but is not really injurious. San hemp is eaten by a brown and black species which appears in abundance in the rains. Brinjal is liable to attack, as also are indigo, vegetable crops, etc. Rice in Burma is attacked by another species (fig. 239), and there are doubtless many yet to be found.

In general the presence of these insects may be disregarded unless they come in extraordinary numbers or are infesting small plots of valuable experimental crops. No treatment will affect the larvæ if they are in the plants. Spraying with lead arseniate poisons the beetles; Bordeaux mixture is a specific for these beetles when properly prepared and sprayed on the plants. The bag is a useful mechanical method on wheat or rice and its effect is enhanced by oiling the inside of the bag with kerosene or heavy oil.

Epilachna Beetles.

On brinjal (*Solanum melongena*), turia (*Luffa acutangula*), dudhi (*Lagenaria vulgaris*) and other cucurbitaceous plants, and on many wild plants, one finds small round beetles shaped like a half pea, of a dull red colour with black spots. They feed upon the leaves, taking a series of bites off the epidermis and producing a very characteristic stippled appearance: with them are often their larvæ, small oval grubs, yellow and very spiny.

FIG. 240.
Epilachna Beetle.
On the right the antenna, on the left the leg.

These beetles belong to the true lady-bird beetles which normally eat plant-lice, mealy bugs and scale insects; the epilachnas alone are herbivorous both as larva and imago.

The life history is similar to that of the rest of the family; the eggs are cigar-shaped, yellow, laid in clusters, each egg on end side by side. Mr. Haymann found that one beetle laid 280 eggs.

The eggs hatch in about five days, the young feeding at once upon the epidermis of the leaf. When full grown the larvæ are one-quarter of an inch long, flattened and oval covered with short spines. They cling tightly to the leaf and move slowly. They live from three to four weeks, and pupate on the leaf, the pupa being attached by the tail. The larval skin is not completely thrown off; after four to six days the imago emerges.

These insects are most abundant from July to November, there being several broods during that time. The beetles live through the cold weather and emerge about March, when they often couple and lay eggs if a food-plant is available.

As in all beetles of this family, they can live for long periods until fresh food is available. They are injurious simply by destroying the leaves and under favourable circumstances become abundant. Garden crops are injured, field crops practically never. In gardens the simplest

way is to destroy the beetles by hand-picking, an easy matter when they are few. The danger is that useful lady-bird beetles may be collected by mistake, but if the yellow spiny grubs are found, as well as the beetles, it is fairly safe to destroy them. To any one who has seen both kinds of beetles, there is no difficulty in discriminating the epilachnas. In serious cases, a spray of lead arseniate is a radical cure and this will destroy only the epilachnas, the beneficial beetles not eating the poisoned leaves.

Fig. 241.
Orange Banded Blister Beetle.

Blister Beetles.

The beetles figured here are probably familiar to every one who observes insect life in the plains; they represent the most common species of this group in India. Blister beetles are characterised by having a somewhat soft integument, a distinct neck between head and thorax, and elytra which do not fit tightly to the side of the abdomen but look as if they belonged to some other insect. On handling them, an acrid yellow liquid exudes from the joints of the legs. They are moderately large insects with good powers of flight and may be found by day in flowers or on the ground. These insects appear in August, September and October and feed upon the flowers of plants; exceptionally they feed upon the leaves of plants, one species emerging in the lower hills in vast numbers in May and eating certain weeds. Three species are prominent in the plains, recognisable by their colouring. The Banded Blister Beetle [1] is black with variable bands of orange across the elytra; the size and colouring are very variable, orange or black predominating. This species is common throughout the plains and fields from August to November or later. It appears in large flights, settling in gardens and destroying the flowers of pumpkins, cucumbers, melons hibiscus, cotton and other large-flowered plants. It is slow in flight and easily captured by hand or with a small net. The Green Blister Beetle [2] is a smaller slender insect, the elytra a vivid green, the neck reddish. It is associated with the Brown Blister Beetle,[3] a

Fig. 242.
Orange Banded Blister Beetle.

[1] 50. *Mylabris pustulata.* Fabr. (Cantharidæ.)
[2] 40. *Cantharis tenuicollis.* Pall. (Cantharidæ.)
[3] 39. *Cantharis rouxi.* Cast. (Cantharidæ.)

beetle similar in shape but of a dull brown colour. These two damage a variety of crops, including sorghum, rice, kutki (*Panicum miliare*), bajra (*Pennisetum typhoideum*), etc., by destroying the flowers; large numbers emerge as these crops flower and settle on the head, biting the anthers and stigmas so that seed is not formed.

FIG. 243.
The Green Blister Beetle.
(Slightly magnified.)

This results in a large or total loss of grain. The attack is very sudden, and requires to be checked at once. The insects feed principally in the morning, hiding in the earth or on the plants during the hot part of the day; they remain only a few days and again disappear. This form of damage is by far the most important caused by these beetles and is observed or reported yearly in some districts of India.

No other species are known to be destructive in India although others will probably be found to be so. Several blue species are common in the plains but perhaps appear at a time when no crops are in flower.

The life history of these beetles is unknown, but there is scanty evidence that it will prove to be similar to that of European and American species. The eggs of two Indian species are laid in large masses on the soil and active grubs hatch which run about the surface. The life histories of those worked out elsewhere are of extreme interest, being passed in the nests of bees or wasps, or in the egg masses of locusts. The active larva that hatches from the egg attaches itself to a bee and is carried to its nest, or seeks out the egg mass of a locust. In all cases known the larval life is a semi-parasitic one, and there is a curious metamorphosis in the larval life, the larva assuming two or more distinct forms at successive periods.

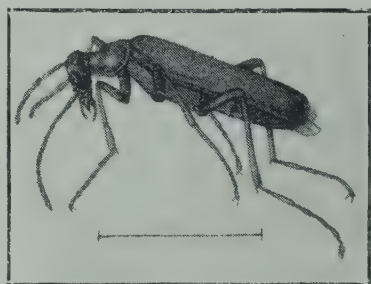

FIG. 244.
Brown Blister Beetle.

Blister beetles are useful in medicine, the oil of certain species having the power of blistering the human skin. The extract of the dried beetle is used for this purpose. In India these beetles are used in a somewhat similar manner. In Baluchistan, for instance, the "Gojak" beetle[1] is soaked in milk and the fluid poured on the bald spots to cure mange (R. Hughes-Buller). When the beetles

[1] Closely allied to *Mylabris pustulata.*

attack crops, vigorous measures must be taken at once to drive them out. Hand-collecting is laborious; active boys with hand-nets will catch far more, and a simple hand-net of bamboos and muslin is easy to make (figs. C and D, page 289).

Fires covered with green materials are useful if the smoke hangs in the crops and the air is still. In the case of low crops such as rice, the useful bag can be run through quickly, and where they are taller, a rope or a strip of cloth can be fixed to two bamboos and pulled over the ears; vigorous measures to worry the insects in the morning are all that is required and in a few days the seed is set and the beetles disappear. In gardens, the banded beetle destroys flowers; there is no remedy available but to collect them by hand or with the net, which is not difficult as the flights of beetles soon pass away. Collected beetles are easily killed in hot water or in water with a film of kerosene over it.

FIG. 245.
Brown Blister Beetle.

Palm Beetles.

Two beetles, of distinct habits and appearance, attack palms, including the toddy, palmyra and cocoa-nut-palm. Each is destructive in a distinct manner and both are found widely spread over the plains of India. The two cannot be confused in their appearance or their work.

The Rhinoceros Beetle[1] is a large thick-set black beetle, somewhat over two inches long and one inch broad; its appearance is best realised from the figure.

This insect flies at night, coming into houses attracted by lights. It feeds upon the soft tissues of the palms, attacking the unopened leaf or the base of the fruiting

FIG. 246.
The Rhinoceros Beetle.

[1] 126. *Oryctes rhinoceros.* L. (Scarabæidæ.)

stem and eating its way into the soft heart of the plant. In so doing it injures the rolled up new leaves, which show signs of its work when they open, and wounds the tree. In itself it does little harm and in Ceylon is kept in check by extraction from the tree with a stiff wire. Mr. P. B. Haig has reported that in Kanara this beetle kills the cocoanut-trees occasionally and that an attacked tree yields no toddy.

Its life history is known to the toddy-tappers, who find its grub in dung heaps and in decaying vegetable matter. The grub is an immense soft white larva, legless and of a most striking appearance; it is quite common in dung heaps and decomposing vegetation. The beetle really does injury by attracting the more serious enemy to the palm tree, the Red Weevil. This insect comes to trees wounded by the Rhinoceros Beetle and lays eggs in the wound. For this reason it is desirable to check the beetle by the destruction of its young and by capturing it on the attacked trees.

Fig. 247.
Palm weevil. Below, the Cocoon.

The Red Weevil[1] is a more slender insect, of a red-brown colour, with a conspicuous curved snout, about one and a half inches long. Its life history is as follows. The weevil lays eggs singly in the tissues of the palm-tree by means of her long ovipositor; these eggs are deposited in the wounds made by the Rhinoceros Beetle, in cuts made by tapping, in cracks or at the base of the leaf stalk; in fact wherever in the tree the weevil's ovipositor reaches the tender tissues, she lays eggs. In Ceylon it is said that the eggs are laid only in trees that have reached the fruiting period, but this is not yet certain. The grubs that hatch tunnel in the soft tissues, feeding on them and gradually working down

[1] 141. *Rhynchophorus signaticollis.* Chevr. (Curculionidæ.)

into the stem; a large number of eggs are laid in each plant and sooner or later the plant probably dies. The grubs when full fed prepare a cocoon of the twisted fibres of the stem; how the grub in the seclusion of the stem is able to prepare this cocoon is one of the marvellous things in the life of this insect. The beetle presently emerges from this cocoon and comes out of the tree.

The life history in this case probably occupies one year but has not been ascertained in India. The insect is destructive to cocoanut palm in Ceylon and the Straits Settlements; another species is injurious to palms in Honduras and the West Indies in the same way. A great deal has been written about these insects in these countries, where they are far more important than in India. In Ceylon legislation is proposed against them, the law compelling every owner of trees to take certain measures against the weevils.

All remedies are directed to two ends, to prevent egg-laying in the palm-trees, to destroy all weevils that breed. For the first, the Rhinoceros Beetle must also be destroyed and in Ceylon this is done. Secondly, the cuts made by tappers must be so treated that the weevils cannot lay their eggs there; this is effected in Gujarat by smearing the cut with the juice of *Euphorbia neriifolia*. Blandford suggested a mixture of tar and sand for the Honduras weevil, and it is likely that, if available, tar would do equally well in India. As it is, clay must be used or any other substance which the tapper can obtain and which will keep the weevil from the cut. This treatment must include other cuts and wounds, in fact all openings at which the weevil could lay eggs.

To destroy the weevils it is necessary to burn badly attacked trees, and the legislation in Ceylon is designed to make this compulsory. A tree that is infested and dies is a source of danger to all since the weevils that are in it come out and infest other trees. Where trees are only lightly attacked and the attack is seen in time, the grubs are cut out and the wound treated with tar and mud. Mr. Green in Ceylon has got better results by treating attacked trees with carbon bisulphide and this is deserving of trial in India.

CHAPTER XVII.

LOCUSTS, GRASSHOPPERS, SURFACE BEETLES AND BURROWING INSECTS.

LOCUSTS are probably the most familiar pests discussed in this volume and are here treated with the grasshoppers and other orthopterous insects to which they are allied. Locusts do no great aggregate harm compared with the attention they attract, though the sight of fields stripped by a locust swarm is very impressive. If money values could be ascertained, any one of the major pests probably does more aggregate damage, working constantly, scattered over all India but not laying waste a tract in the thorough manner of the locust.

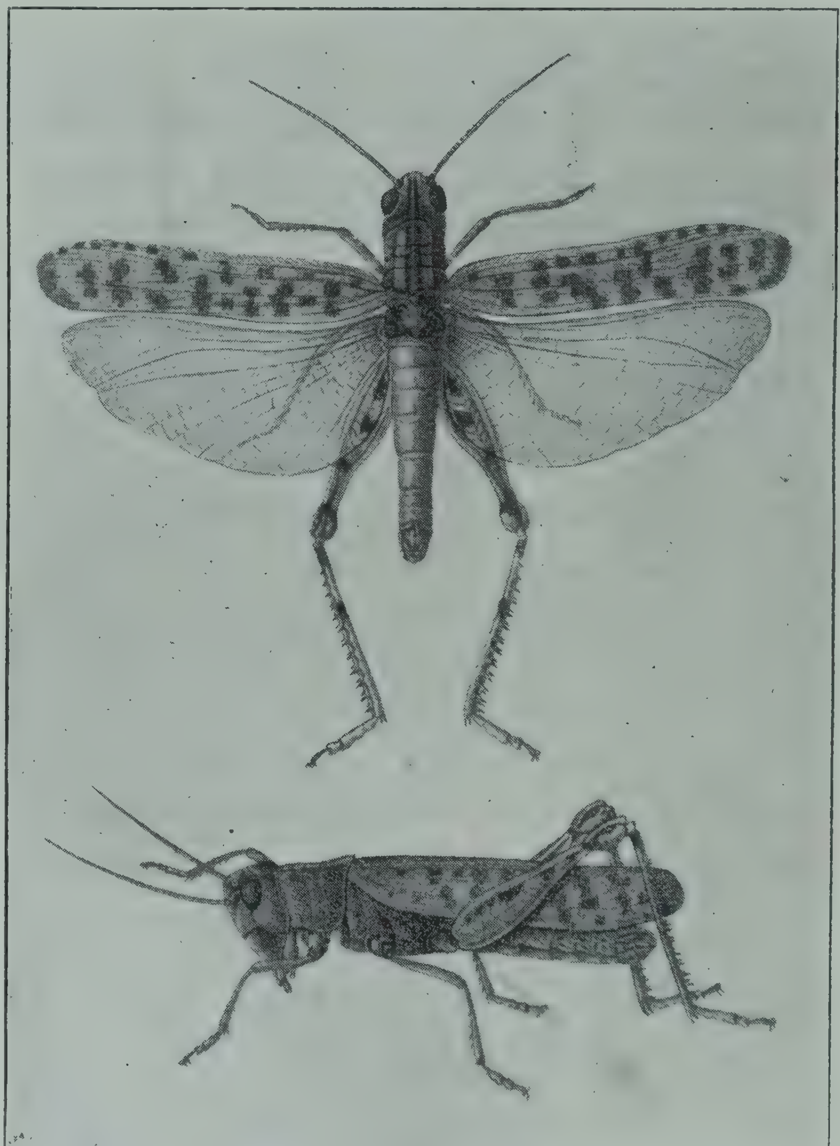

FIG. 248.
A Common Grasshopper.

Surface grasshoppers, which do a great amount of harm in India, are here separated from the ordinary grasshoppers and discussed as a distinct class of pest (page 220).

Grasshoppers.

Among the most common insects are the grasshoppers, active insects which live in fields and jungles, leaping and flying readily when disturbed. They are recognisable most easily by the very large hind legs, with which they leap. The body is hard, not hairy or covered with scales; the wings project beyond the end of the abdomen and are often coloured, the antennæ are quite short.

Grasshoppers and locusts together make up one family of insects. It is generally supposed that any large grasshopper is a locust and this word is commonly used without a clear idea of its true meaning. When an insect belonging to the family called grasshoppers becomes exceedingly numerous and forms large swarms, which migrate from place to place, it is called a locust.

There is no difference in structure between locusts and grasshoppers; the distinguishing feature of the locust being that, when very abundant, all collect together into swarms and move from place to place.

There are many large grasshoppers in India which never form into swarms and migrate; only two true locusts are known in India, and these are almost identical with the large grasshoppers (pages 212-14).

Grasshoppers occur throughout India in the plains, and in the hills up to the snows. Many species live in the forests, others in grass lands, a few in the crops and cultivated land. The life history of all is not known in detail, but all have similar habits. The female lays eggs in the ground, depositing them in a compact cluster. The young that hatch are very small, active insects which resemble the full grown insects in general appearance. They have no wings when first hatched, which appear only after there have been several moults and the insect is half grown. As in all insects the wings are fully developed with the last moult. It must be remembered that any grasshopper, however small, that has fully developed wings and can fly, is full grown and can grow no further. The number of moults varies with different species, from five to seven or, exceptionally, eight.

The wings appear after the third moult as very small lobes on the second and third thoracic segments, growing larger at each moult. The colouring of the young grasshopper is commonly distinct from that of the full grown insect and may change at least twice during nymphal life. This is due to the changed environment of the insects at different

periods or even to the changing colour of the vegetation as the season advances.

In general the young are coloured green to accord with the green vegetation in which they live, and the adults in greys, browns, and neutral tints which blend with the light and shade of the drier grass or vegetation in which they live. In no group of insects is this form of protective colouring so universal or so beautifully shown. Rarely they are strikingly coloured and exhibit "warning colouration" in conjunction with unpleasant taste. So far as is known grasshoppers are exclusively herbivorous. The period of the life history varies greatly and only a few species have been worked out. Some hibernate as eggs, others as perfect insects and there may be one, two or several broods in the year.

The two locusts and the Rice Grasshopper are dealt with separately (pages 214 and 119); a separate section is also devoted to the ground grasshoppers which injure crops in a special manner. Few other grasshoppers are known to be destructive, though a number of species have been sent in as pests or as locusts.

The Painted Grasshopper[1] is a large species coloured in blue and

FIG. 249.
The Painted Grasshopper.

yellow when full grown, found abundantly on the akh plant (*Calotropis spp.*). Its young are coloured yellow with black stipples and red spots, exhibiting warning colouration as do the parents. The Black-spotted Grasshopper[2] is a large species coloured in black, brown and white, which lives in the crops and feeds specially upon cotton. The young (fig. 251) are green with a pink stripe at the posterior edge of the thorax; this species is found at all seasons of the year, having no regular broods.

[1] *Poecilocera picta.* F. (Acridiidæ.) | [2] 49. *Acridium aeruginosum.* Burm. (Acridiidæ.)

It is constantly confused with the Bombay Locust which it closely resembles.

FIG. 250.
The Black-spotted Grasshopper.

Another large species very common in the plains is the Snouted Grasshopper;[1] a long slender grasshopper characterised by the sharp

FIG. 251.
Young of Black-spotted Grasshopper. Colour green. First, second and penultimate stages shown.

[1] *Tryxalis turrita* and other species.

head and flat antennæ. It is green or coloured in a beautiful combination of browns which make up a general 'dry grass colour.' There are

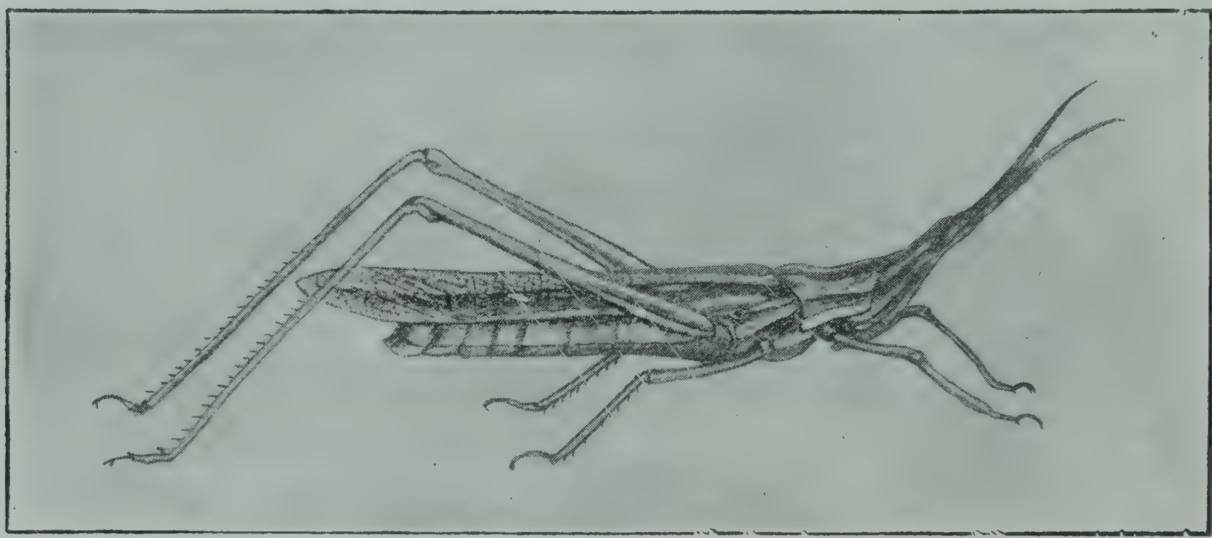

Fig. 252.
The Snouted Grasshopper.

a large number of smaller forms common in the plains and still more in the hills. None can be reckoned to be specific pests of special crops.

The principal safeguard against grasshoppers is clean cultivation; fallow lands should not bear a crop of weeds and waste lands should grow good grass. Waste strips between fields are a constant danger unless fed down or planted with one variety of grass. When grasshoppers appear in numbers in crops, an attempt should be made to trace them to their breeding place, which is probably waste land near by.

Locusts.

Two species of 'grasshopper' come within our definition of locusts, that is, grasshoppers that form swarms and migrate. These

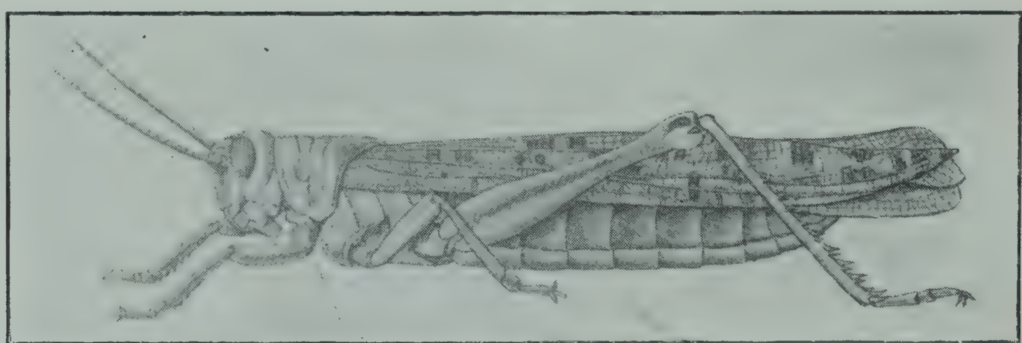

Fig. 253.
The Migratory Locust.

are the Migratory or North-West Locust[1] and the Bombay Locust.[2]

[1] 66. *Acridium peregrinum.* Oliv. (Acridiidæ.) | [2] 46. *Acridium succinctum.* L. (Acridiidæ.)

Other species may prove to be locusts but have not migrated in swarms in recent years.

These two species are constantly confused, not only with each other, but with such insects as the Black-spotted Grasshopper and other large grasshoppers. Both are over two inches in length and half an inch across the thorax; this eliminates all but a few insects in India. Green does not enter into the colour scheme of either. The North-West Locust is a uniform purple red or yellow with no stripes, with wings uniformly spotted from base to apex and with indented lines round the prothorax. The Bombay Locust has streaks of colour on the prothorax and wings, very faint indented lines and is very variable in colour. It can be at once distinguished from the North-West Locust

FIG. 254.
The Bombay Locust.

by its stripes and by the absence of indented lines. It will, however, be confused with the Black-spotted Grasshopper which is of robuster build, conspicuously blotched in black and white, with a large white blotch on the side of the prothorax; the latter never varies in colour.

The figures above help in distinguishing the species, but owing to the colour variation of the Bombay Locust it will always be confused with the other species unless actual specimens are examined.

The *North-West Locust* extends over Baluchistan, North-West India, South Afghanistan, Persia, Arabia, Cyprus, and Northern Africa, with permanent breeding grounds in widely separated localities in this vast area.

From North-West India it extends in a general easterly and south-easterly direction over the Punjab, Central India, the northern division of the Bombay Presidency into the United Provinces, Bengal, Assam and as far south as Madras.

The permanent breeding grounds appear to be in the sand hills of Western Rajputana, in Baluchistan, Southern Afghanistan and Persia; from these places swarms fly over Rajputana into India. This locust lays its eggs in sandy places, depositing a single mass containing from fifty to one hundred eggs. These hatch in about three weeks and the hoppers are at first green, later black. They are said to moult four times, but probably do so more often. Maturity is said to be attained in from one to two months, after which they form into swarms and fly. Within another two to four months they couple and lay eggs provided a suitable spot is found.

The whole life apparently occupies from five to seven months and there are in India two broods in the year. There is apparently no regularity in the periods of egg-laying, which depend upon the amount of food available and the local conditions. An insect that migrates over vast distances will probably have changed habits in various localities

FIG. 255.
Eggs and Nymphs of the Migratory Locust.

and be dependent upon climatic conditions. Whilst the winged insects have the usual habit of flying in swarms, the young form swarms which move over the ground and devour all green stuff within reach. In this

state the destruction is enormous since the insects strip whatever vegetation they encounter. The winged insects may be as destructive, but as a rule their ravages, being spread over longer distances, are not felt so acutely.

A great deal has been written about the North-West Locust and advantage is taken of its peculiar habits to destroy it wholesale. The reader should consult the long article in the Journal of the Bombay Natural History Society for 1891 (page 242).

The essential features of this locust are that it has permanent breeding places in North-Western India from which it migrates; that it apparently breeds twice a year and lays its eggs in special sandy places, and that the young form swarms which hop from place to place. It is possible to destroy the eggs in the permanent breeding places or at least to destroy them when they lay eggs in accessible places; it is also possible to destroy the armies of hoppers by simple mechanical methods; these two measures are extensively carried out against this locust in Cyprus and Algiers and form the basis of methods of checking the pest.

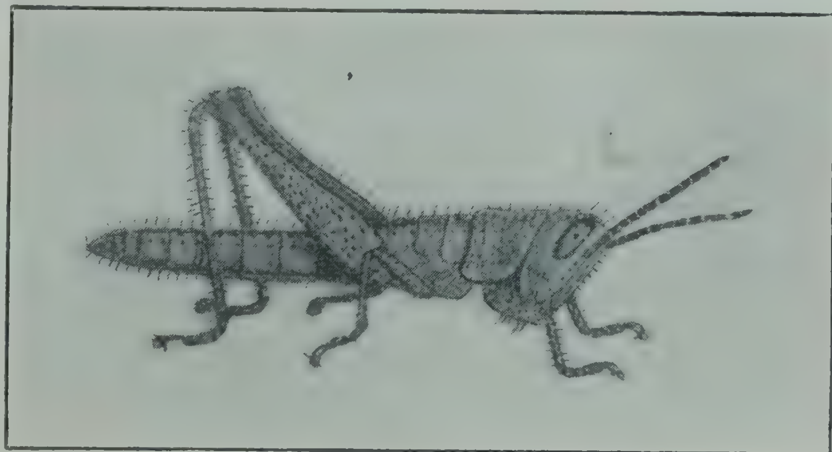

FIG. 256.
Young Bombay Locust after third moult.
(Magnified five times.)

The Bombay Locust breeds most extensively near the Western Ghats, a line of forest hills bordering the sea from the Thana District to Coorg, the chief breeding ground being in the neighbourhood of Goa, not in the forest but outside in the open grass lands. It also breeds all over the plains of Southern India in suitable places, and is found in Assam, Burma and throughout the whole of Peninsular India. Where it becomes abundant, it assumes the characteristics of a locust; elsewhere it is an ordinary grasshopper, forming part of the regular plains' fauna.

From the Western Ghats it spreads in swarms over Bombay, Mysore, parts of Madras, over Hyderabad, the Central Provinces and parts of Central India.

This is exceptional and occurs only rarely. This locust breeds only in damp places, laying its eggs in wet soil; it lays a mass containing

about one hundred eggs (fig. 25), which hatch in about six weeks. The young are green and complete their development in about two months (figs. 27, 28, 257, 258).

Eggs are laid with the first heavy rains in June or July and the perfect insect emerges in October. From October to June it lives as a flying insect; its colour is at first brown with light stripes, forming the 'dry grass' colour which is protective to it in the long dry grass in which it lives. It then forms swarms and becomes suffused with a vivid red, which persists during about four months; throughout this time it lives in immense swarms in the Ghat forests until in April and May it scatters. In 1904 these swarms spread over an immense area and in May broke up, single locusts being found scattered throughout this area. This is preliminary to coupling, which commences with the rains; the locust now assumes a darker colouring, the red giving place to blacks and browns; this colour scheme hides the insect when sitting on wet grass-land or soil where it lays its eggs.

The life cycle occupies one year, and egg-laying is performed at this special season. The young are found scattered through the long green grass during the rainy months and do not form swarms. The

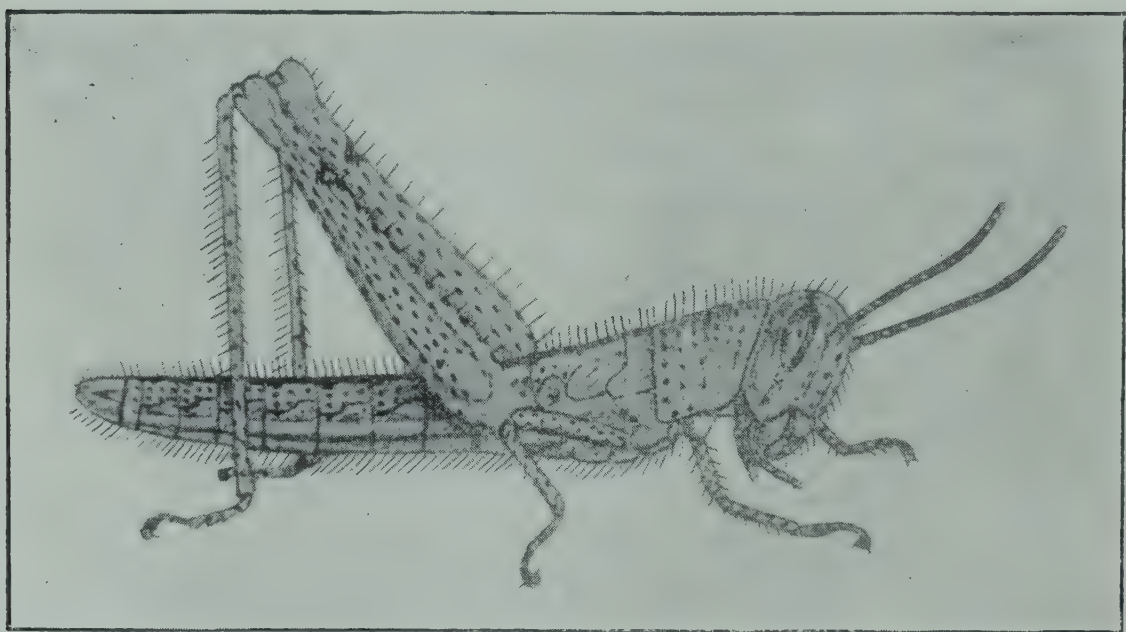

FIG. 257.
Young Bombay Locust after third moult. (Magnified five times.)

earliest swarms are found in October when, as the grass ripens, the insects enter the crops, feed there and then migrate back to the forests. The forest region is, therefore, the home of this locust which migrates only to breed or when extraordinarily abundant.

The damage is caused entirely by the winged locusts, first in the ripening kharif crops, later in the hilly districts during the winter months.

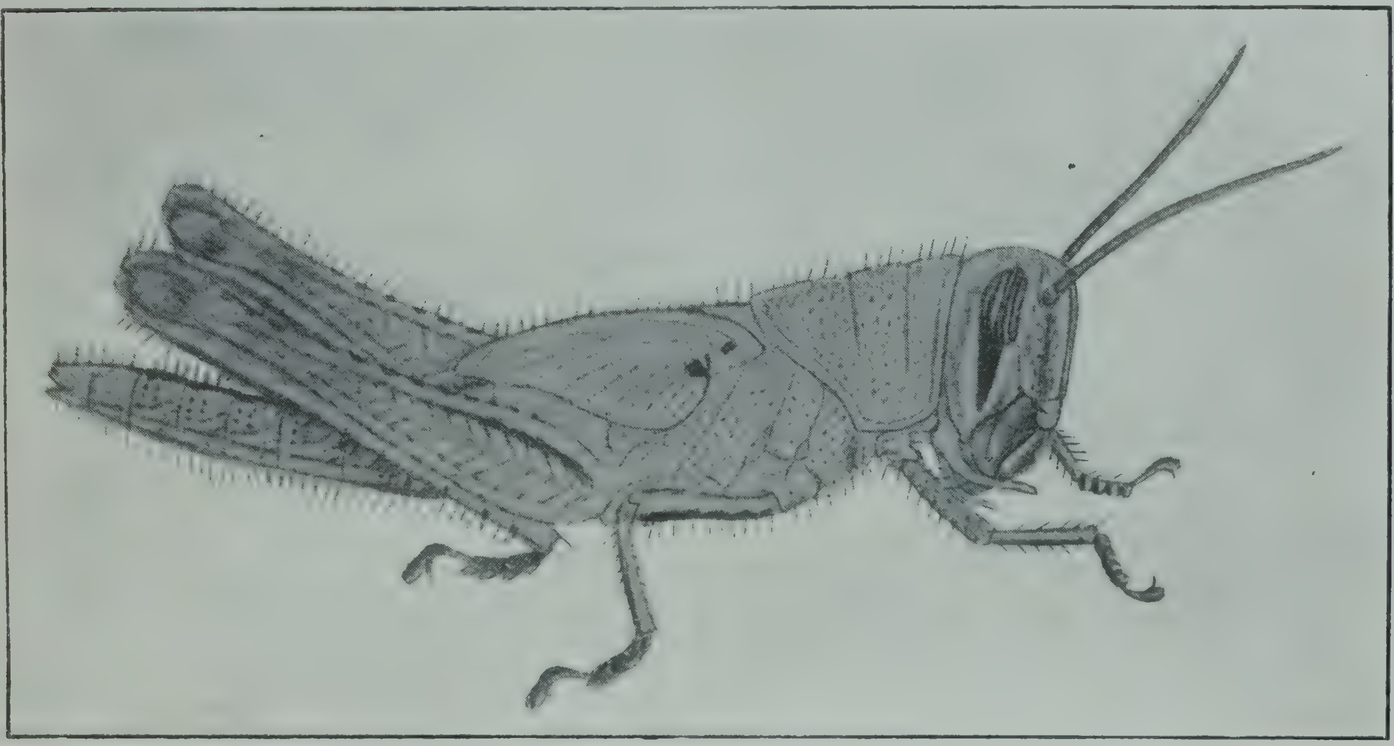

FIG. 258.
Bombay Locust, before the last moult. (Magnified twice.)

The methods in use against the North-West Locust are here impossible owing to the different habits. The eggs are rarely found in large numbers and are usually scattered over a large area. The young are not found in swarms but scattered in grass-lands. The winged insects fly in swarms for several months and live for eight months in all. The measures actually adopted against this locust included the destruction of the hoppers by means of bags and cloths, the destruction of swarms at night during the cold weather, the destruction of coupling locusts by hand and the collection of eggs, all under the inducement of rewards paid for the amount collected. The Bombay Locust appears to have emerged in immense swarms in 1883-84 and in 1903-04. A full account of the latter outbreak has been published separately.

Locusts in India, as elsewhere, are attacked by parasites and enemies. The winged individuals are infested by the young of a large red mite[1] and are parasitised by at least one and possibly more species of parasitic flies.[2] The eggs are parasitised by an ichneumon and a fly, are eaten by grubs and are infested with a peculiar worm. Crows

[1] 17. *Trombidium grandissimum.*
[2] *Miltogramma duodecim punctata.* Big. (Tachinidæ.)

eat locusts and destroy their eggs and the 'rosy pastor' or *juari* bird is supposed to destroy a large number of winged locusts.

It is probable that other species of grasshoppers will be found to form swarms and behave as locusts under exceptional circumstances, but no species are known to do so at present in India. There has been great confusion on this point owing to the difficulty of identifying insects believed to be locusts. It is probably correct to say that, except in the case of small local swarms, no insect except the two discussed above can be regarded as a true locust in India.

Fig. 259.
Fly parasitic upon Locusts.

Surface Beetles and Grasshoppers.

A number of insects confine their attacks to young plants just out of the soil, destroying the germinating plants as they push above the surface and preventing the crops from becoming established. These

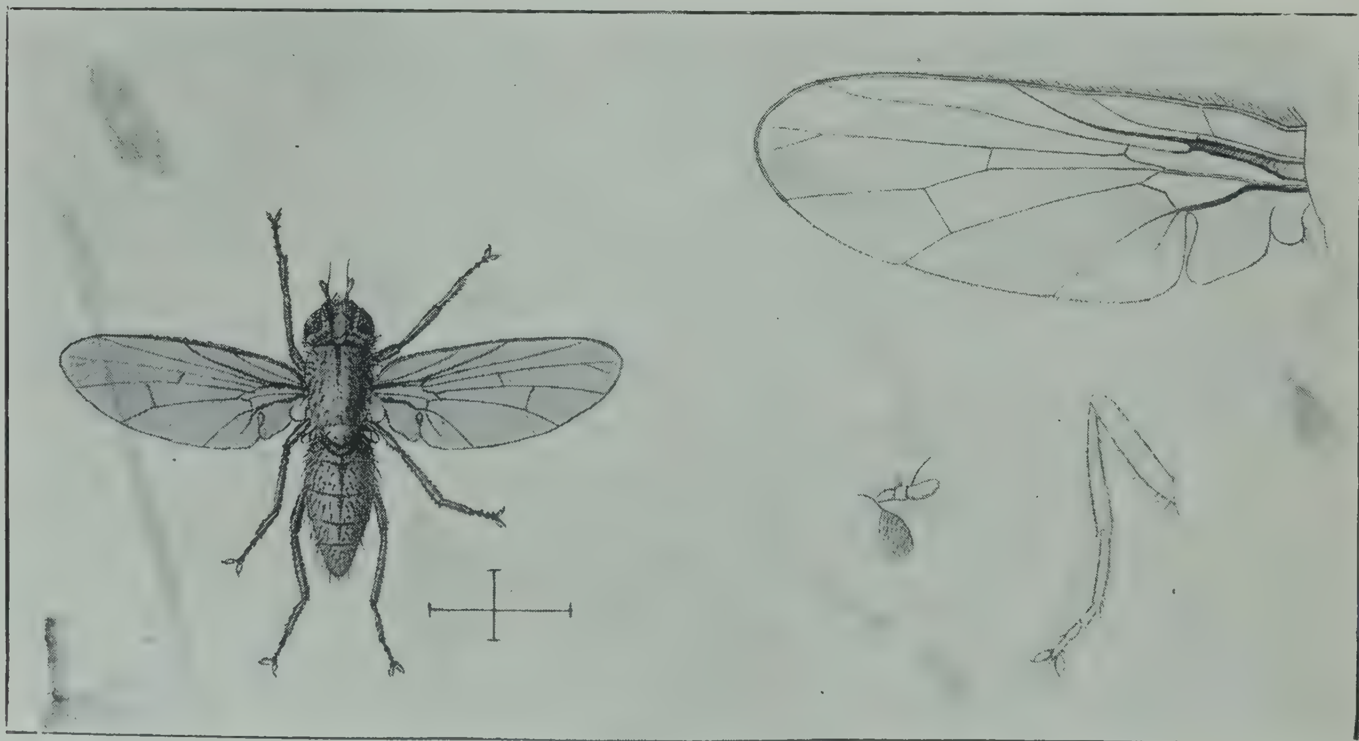

Fig. 260.
Fly parasitic on the Eggs of the North-West Locust. (Magnified.)

pests are of very general occurrence throughout India both in field and garden crops. They form a clearly defined group of pests, including insects of widely separated affinities, but united by their peculiar habits and methods of feeding.

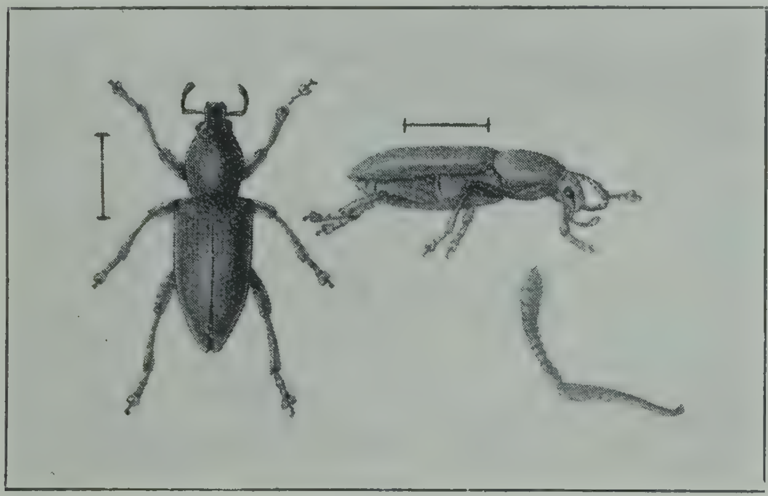

Fig. 261.
Surface Weevil. (Magnified.)

All are adapted to living on the surface of the soil; most are of the dull brown colour of the freshly ploughed earth and are difficult to find when at rest on the surface: they include the surface beetles, small earth-coloured weevils, not exceeding one quarter of an inch in length, similar to the species figured here: also the surface grasshoppers, which are either flattened, with a rough upper surface and exactly earth-coloured, or they are similar to the common grasshoppers but coloured in brown so as to escape notice on the soil.

The beetles live on the soil, hiding in cracks, under stones and in burrows; they emerge daily and feed on the young plants, being very abundant at the time when the kharif or rabi crops are sown. Their life histories are unknown, the grubs being probably borers in wild plants. The grasshoppers are similar in their life histories to others of this group; they lay eggs in the soil, from which the little hoppers hatch; the whole life is passed in the fields and under favourable circumstances they become very abundant. Most breed rapidly and regularly, with several broods, but some appear only at regular intervals such as once or twice in the year. All are herbivorous, and their ravages in the established crops are not observed as they are not sufficiently numerous to do harm. They are injurious to germinating

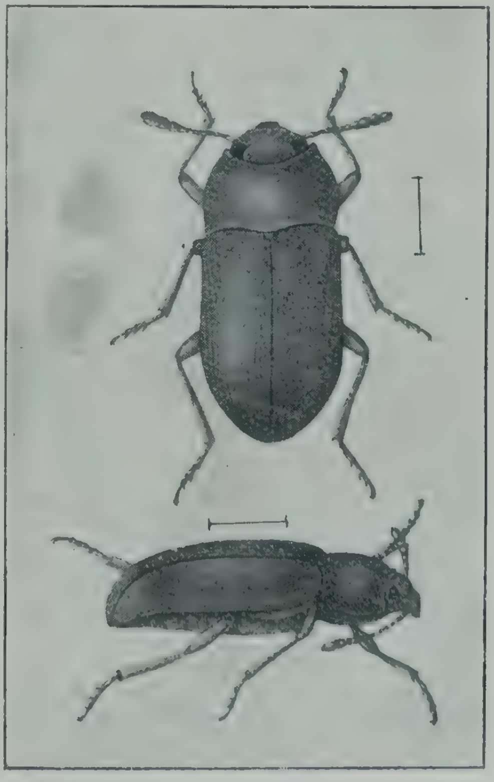

Fig. 262.
A common Ground Beetle that feeds on decaying leaves and is mistaken for a pest. (Magnified.)

crops owing to the peculiar conditions; large areas of land are cleaned, weeded and sown; there is no food in the fields but the germinating seeds, which offer a peculiarly tempting diet to these insects; a few insects can destroy a very large number of these tender shoots and the destruction becomes very serious; the crop is resown and again eaten. The destruction of successive sowings and the delay in establishing the crop may prove very serious, and there are many cases where the crops cannot be established. The attacks are more general in rabi sowings but occur in kharif sowings especially when heavy rain has not checked the insects. Early sowings are most attacked under some conditions, later ones under others, which is a matter of climate and rainfall.

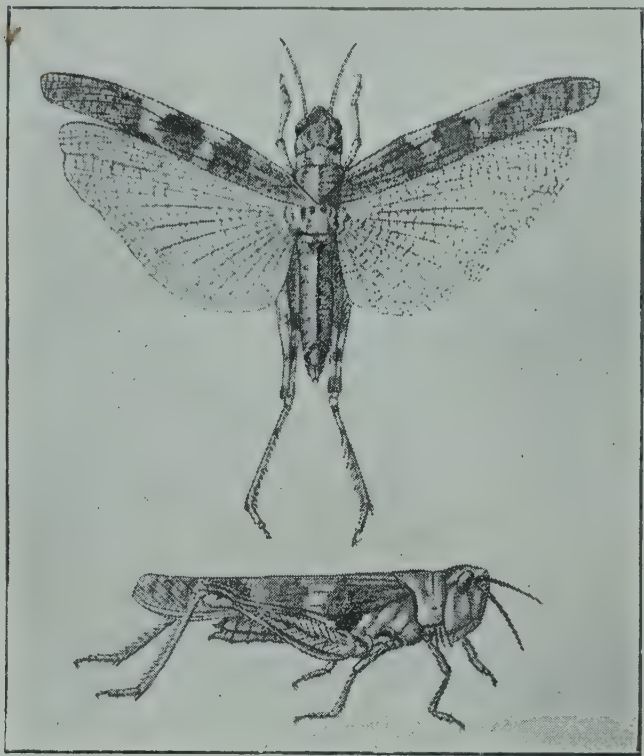

FIG. 263.
A common Surface Grasshopper.
(Slightly magnified.)

Wheat, barley, oats, opium, tobacco, maize, sorghum, cane, gram, cotton, minor millets and vegetable crops are all attacked, and these insects have been observed or reported from widely separated districts of India. The number of species concerned is not fully ascertained and it is unnecessary to distinguish them.

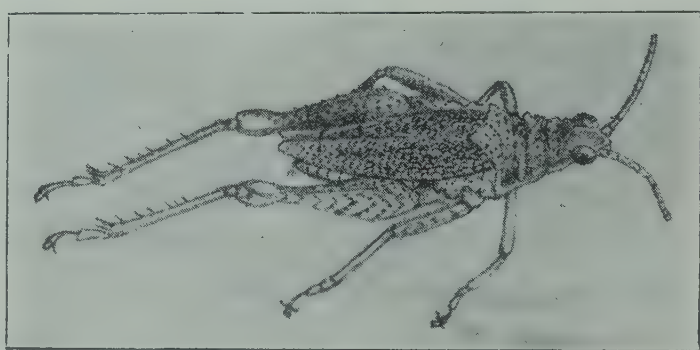

FIG. 264.
The small Ground Grasshopper.
(Magnified twice.)

The methods of treatment vary according to the nature of the crop and the insect. One general preventive is available in almost all cases, which is to provide the insects with alternative food so that they will not eat the seedlings. The common weeds and grass in the field will provide this where it is possible to defer weeding until the seed is well germinated and established. Where this is not possible, another crop can be sown lightly over the field so as to germinate earlier and provide food. The cultivator

of opium in some parts of India sows mustard with his opium to protect the latter, weeding out the mustard when no longer required. Sowing maize with cotton, or sorghum and maize with cane effects the same object. The practice of sowing mixed seeds in irrigated plots serves the same purpose, the valuable plants being protected by the dense growth which is removed as soon as the plant is established.

In Gonda (Oudh) the opium cultivator is said to strew chips of pumpkin through his field to attract the beetles which gather there and are destroyed. This is the simplest and most rational method, whenever it is possible. In the case of grasshoppers only, the ordinary bag and frame can be run over the fields to sweep up the grasshoppers when the seed is sown. This will not collect the beetles which do not jump in the air when the bag approaches and can be used only against grasshoppers. The necessary expenditure of a few rupees for bags and an anna or so an acre for labour is well worth incurring where grasshoppers are abundant.

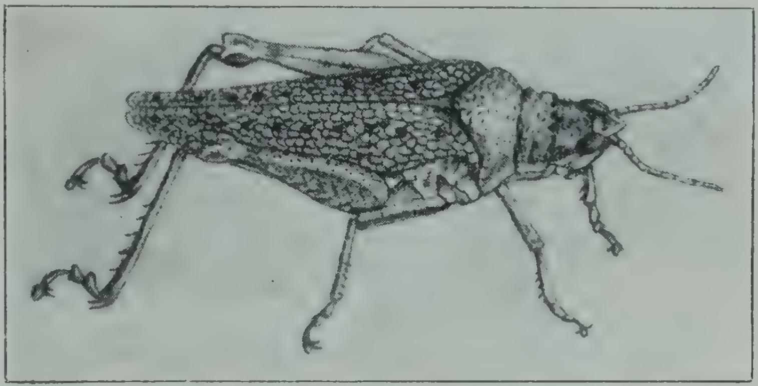

FIG. 265.
The large Ground Grasshopper.
(Magnified twice.)

Flooding is useful where it can be practised, as in opium cultivation, the weevils and grasshoppers both being captured or drowned. Transplanted tobacco has been preserved by spraying the plants with lead arseniate and by dipping the seedlings before transplanting in the mixture of lead arseniate and water. These plants are then poisonous and destroy the grasshoppers on a large scale.

In the case of maize, sorghum, cane, and similar crops, dropping lime and lead arseniate mixture into the heart of each plant is also effective and even dry mould has a good effect, the beetles then not eating the delicate inner shoot of the growing plant.

The practice of burning *rab* lands has possibly some value in the destruction of these beetles which are hiding in the soil and would destroy the seedlings. Generally speaking it is advisable, whenever possible, to sow a trap crop or provide some alternative food for both weevils and grasshoppers; this cannot of course be done after the crop is up and is being injured, but the insects can be anticipated in the following season if this precaution is adopted in time. Wherever grasshoppers are known to be abundant, they should be swept up about the

time the crops are sown, together with those in neighbouring strips of grass. If nothing else can be done for the weevils, they should be

Fig. 266.
The Big Cricket.

provided with food, even if it be only heaps of green fodder laid about the fields; large numbers can be captured in this manner and the ingenuity of the ryot is quite equal to finding out the most satisfactory substance for this purpose.

Crickets and Root Insects.

Many insects live in the ground forming burrows which ramify below the surface and open at one or more points. These are principally crickets, insects which are closely allied to the grasshoppers but live below ground.

Many species occur in India whose distribution is not yet accurately ascertained. Only the larger burrowing species are known to be injurious, possibly because the harm done by the smaller species is not attributed to the right cause. These insects make burrows which descend to some distance into the soil, always with openings at the surface; the nature of the soil, and the height of the sub-soil water exercise an influence on the depth of the burrow; the distribution of the various species appears to be limited by the occurrence of the particular soils they need. They descend deeper into the soil

Fig. 267.
The Digger Wasp that preys upon the Big Cricket.

in hot dry weather, coming up in the rains, either owing to the rise of the soil water or because the surface is then moist and cool.

The life histories of the Indian species have not been investigated but are probably similar to those of other species. In the group in general, eggs are laid in a central chamber in the ground, a large number of small round eggs being deposited in a mass and cared for by the parent. The young that hatch are active and sooner or later start their own burrows; they pass through the usual moults. The food is largely vegetable but not universally so and it is probable that certain species are mainly or wholly insectivorous, driving their burrows through the soil in search of the insects. The large brown cricket[1] (fig. 266) is

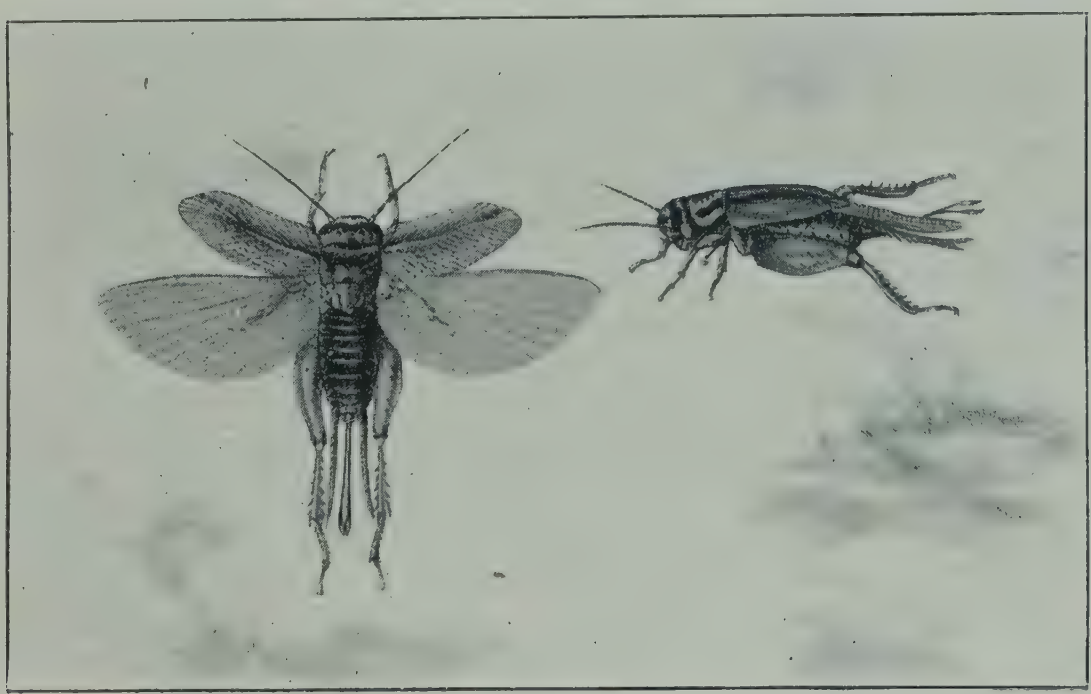

FIG. 268.
The Black-headed Cricket.

herbivorous, making very large and extensive burrows; it comes up at night, cuts off plants, and descends with them to its burrow. This species grows to a great size and is common in Bengal, Bihar, Assam and Burma. In the rains it is driven up out of its burrows and the crows then destroy a large number. This insect is also preyed upon by a metallic green Digger Wasp (fig. 267), which stings it, lays an egg on it and buries it in its own burrow. In spite of this check the insect is a common field and garden pest. Another smaller brown species[2] with a

[1] 51. *Brachytrypes achatinus.* Stoll. (Gryllidæ.)
[2] 272. *Gryllodes melanocephalus.* Serv. (Gryllidæ.)

black head is reported to be destructive to sorghum in Upper Sind and to crops in Shahpur, Punjab (fig. 268).

A widely distributed species is the two-spotted cricket,[1] a black insect with a yellow spot on each wing (fig. 269). It occurs in various parts of India and has been found attacking a variety of crops.

In addition to the injury done by cutting plants, these insects are also injurious to the roots, cutting through the roots in the course of making their burrows. In the rains, when their burrows are near the surface, this form of damage may be extensive.

FIG. 269.
The Two-spotted Cricket. (Natural size.)

The Mole Cricket[2] is particularly injurious in this connection, though there is some reason to believe it is useful in destroying insects, and that it injures the plants only when seeking for pests. This insect is noticeable for the beautifully adapted fore-legs and prothorax, the former broad and toothed for digging, the latter round and hard for forcing through the soil; the abdomen is peculiarly soft. This is a common insect, often found at night in houses, drawn there by the lights.

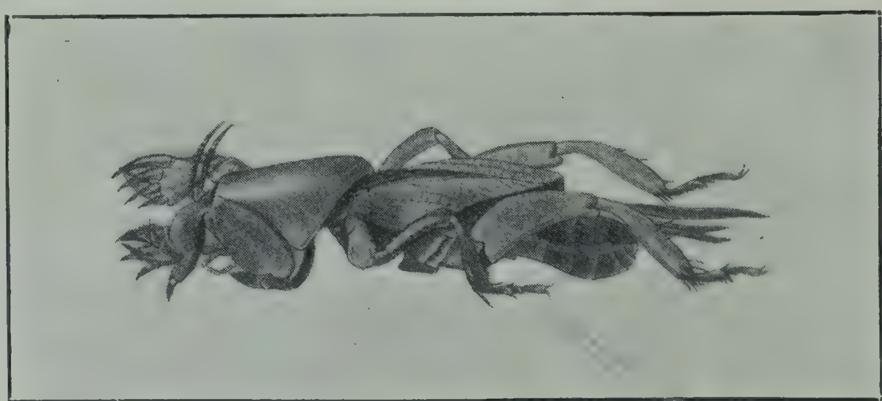

FIG. 270.
The Mole Cricket.

[1] 185. *Liogryllus bimaculatus.* deG. (Gryllidæ.)
[2] 260. *Gryllotalpa africana.* Pal. B. (Gryllidæ.)

Another formidable burrowing insect is not strictly a cricket, but placed in the next family; it is known in Behar as the *bherwa*.[1] This species makes burrows in the soil, usually near rivers and streams; the young are similar to the full grown insects but not winged; the appearance of the winged insect with its most formidable jaws is most

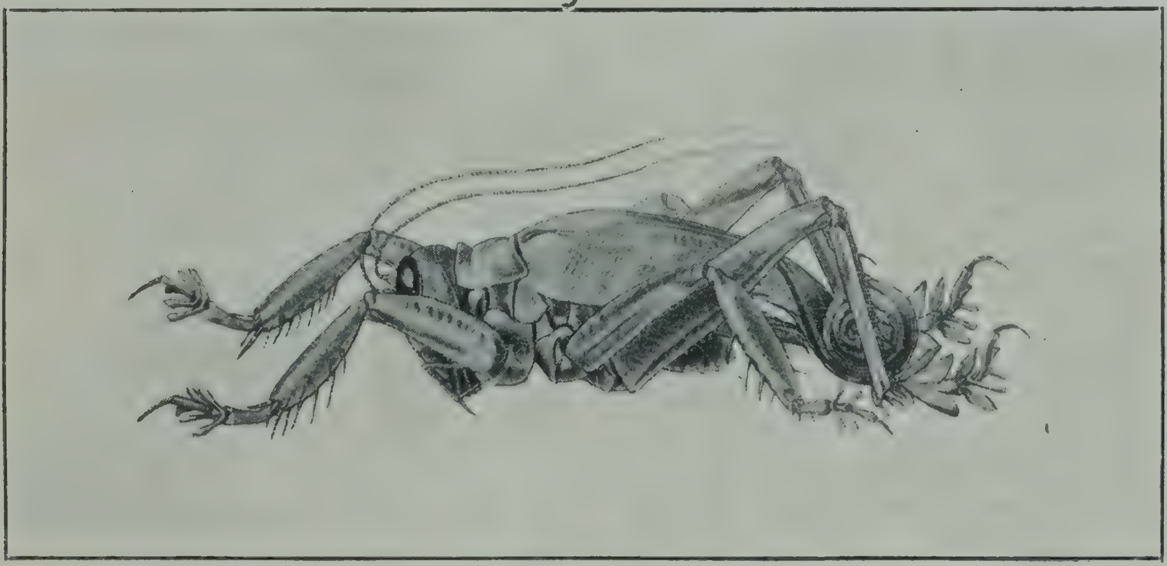

FIG. 271.
The Bherwa.

striking. This insect has been reported as injurious to the roots of plants from several districts of India, cutting through the roots of crops in its search for insects. Normally it lives near running water and is not harmful, but exceptionally it infests fields and does much injury to valuable crops such as tobacco. Its distribution is limited, Assam and Behar being the localities most infested, but it has also been found in a few widely separated localities in India.

Burrowing crickets are extremely difficult insects to check, no good method of destroying them having yet been found. Species that eat crop plants can be poisoned, the attacked crops being sprayed with lead arseniate. The crickets take the poisoned food to their burrows and are there killed. This is effective and simple, a great diminution in their numbers promptly taking place. Flooding out is possible under certain circumstances and is the most radical method, the crickets being driven to the surface and killed by crows and other birds. Digging the crickets out is a slow and laborious method, but the only one available in some cases.

These insects should not be confused with the common insects which live on the surface of the ground and never burrow; the group is a large one and only the burrowing species are really harmful.

[1] 170. *Schizodactylus monstruosus.* Dr. (Locustidæ.)

Termites.

A group of social insects, commonly termed white-ants, which live in nests usually made in the ground. Structurally there is no relationship between the termites, which are *Neuroptera,* and the ants, which are *Hymenoptera;* in their habits there is a close resemblance, with clear distinctions. Termites shun light and never willingly expose themselves

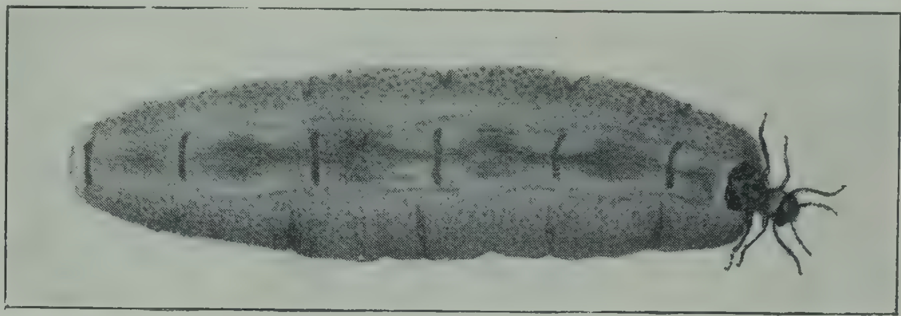

FIG. 272.
Wingless Queen, after return to rest, the abdomen distended with eggs.

to it. The nest is usually underground and from it passages run through the soil to trees, buildings, etc. The nest often projects above the ground and is made of chewed vegetable fibre; it contains many chambers and passages. Within the nest the sexually mature individuals live, the most important of which is the queen who produces the eggs. A colony of termites usually consists of one or more fully developed queens, one or more imperfectly developed queens, and a larger or smaller number of males: males and females alone are winged at any time. The larger part of the colony consists of smaller undeveloped insects, termed workers or soldiers, which never become winged or sexually mature. These leave the nest and collect food for the whole colony. Unless the actual nest is found, only workers and soldiers are seen and it is these which destroy houses, eat crops and damage trees. The nest may be a long distance from the scene of destruction, the termites communicating with the nest by means of a covered passage or a tunnel.

FIG. 273.
Winged Queen Termite.

At certain times of the year, enormous numbers of winged termites

come out of the nests; these fly for a short time and then lose their wings. They are full-grown males and females but they are not fully developed. The greater number, if not all, of these perish, the wings falling off very readily and the insects being eaten by their numerous enemies.

The food of the termites consists of vegetable matter, normally of dead dry timber but also of living plant tissue. It is still an unsettled point whether all termites will attack a sound healthy living plant; they will attack unhealthy living plant tissue, *e.g.*, a cut sugarcane, and it is certain that some will actually eat a sound healthy plant. In general the termites are injurious in buildings, where they utterly destroy wood, leather, paper and similar materials. They also attack mango-trees in parts of Bombay and the Central Provinces; the chilli crop of Gujarat is much attacked as also is sugarcane, wheat, ground-nut and other crops in many parts of India. Exceptionally other crops are attacked, often when in the rainy season the ants are driven up by the high level of the soil water and have to find food close to the surface and not in their usual haunts.

Termites are rarely seen to be attacking a plant or a house until it is too late to take steps against them; they make a tunnel from their nest to the object on which they wish to feed. Should they have to cross an open space or go up a wall, they make a covered way. Having reached their objective they eat into it, removing the tissue and leaving only a shell.

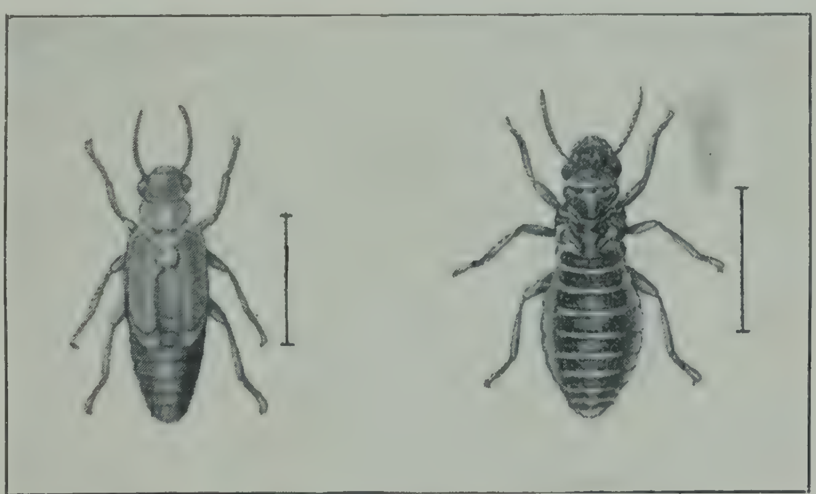

FIG. 274.
Young Termites which will become queens.
(Magnified.)

The treatment of white-ants depends upon the circumstances of each case. The following methods are applicable in special cases:—

(1) If a field is infested with white-ants, search for the nest, dig it out and burn it, taking especial care to destroy any large individuals found in it which may be queens.

(2) If the nest is found but cannot be dug out, pour in carbon bisulphide, kerosene, sanitary fluid, or even abundance of hot water. This will destroy the nest and if the queens are killed the colony will be destroyed.

(3) Where white-ants are prevalent, the woodwork of a house can be protected by a liberal application of any form of arsenic to the door-frames, window-frames, wooden pillars or any exposed wood, as well as to the floors where this is possible. Several forms of arsenic are procurable in the bazaars (white arsenic, *sambul, somal, sanka, etc.*, yellow arsenic, *hartal, etc.*), which can be ground up very fine, mixed with water and poured on. If the floors of all buildings were treated with a solution of white arsenic (formula No. 14) before the top layer is put on, no white-ants would come up through the floor at any time. Termites will not eat through anything impregnated with arsenic and will leave their tunnels if a solution of arsenic comes near. In these cases they may come up outside walls in their covered ways, and will then enter the building if possible. No application of arsenic will check this.

FIG. 275.
Worker Termites of two kinds belonging to one nest. (*Magnified.*)

(4) If a house is infested with white-ants little can be done. If their tunnels or entrances can be found, this can be destroyed and the places treated with arsenic. If they have a nest outside and come into the house, their entrances to the house should be searched out. Fumigation with hydrocyanic acid or carbon bisulphide is as fatal to termites as to all other insects, and where possible every infested building should be fumigated, search made for the termites' tunnels and their future entrance prevented by the use of arsenic.

(5) In fields infested with termites, crops are occasionally attacked, especially sugarcane, wheat and ground-nut. If the nest cannot be found, the termites can be discouraged before the crop is planted, by cultivation. Such crops as sugarcane, planted from setts, can be protected by the treatment of the setts. A cane sett dipped in sanitary fluid, strong soap or copper sulphate (*tutia*) solution or crude oil emulsion, will not usually be attacked by white-ants. This is a very simple and entirely effective treatment. Such vegetable substances as castor cake, asafœtida (*hing*), dekamali gum, etc., are less effectual but still have some effect in deterring white-ants.

Similar but less lasting results follow from the impregnation of the irrigation water with small quantities of poisons. It is necessary to use those which will have no permanent effect on the soil or crop. Crude oil emulsion, sanitary fluid, kerosene oil, pure or in emulsion, are

effectual if introduced in small quantities to the irrigation water. The simplest procedure is to put a bag of the solid, or a tin of the liquid in the water channel so that a small proportion is carried along with the water. This is a practice in Gujarat where a mixture of akh (*Calotropis*), *khursani* (Niger seed), nim cake (*Melia azadirachta*) and castor cake is placed in the irrigation channel in the belief that the white-ants will not attack the chillies.

In some cases nothing can be done to discover or destroy the nests of the termites and no certain method has yet been found of driving away the pest. Good results have been obtained with a top dressing of manure but the best application has not yet been found nor have the results been sufficiently uniform to give reliable methods. It is probable that methods based on this or a similar principle will prove to be effectual in temporarily checking the ravages of white-ants in growing crops and we may hope eventually to be able to free land from termites wholly or for long periods.

(6) Trees that are infested with white-ants can be temporarily cured by the application of kerosene to the bark, or of kerosene emulsion, tobacco decoction, soap solution, etc., to the roots. In Gujarat mango-trees are painted with red ochre (oxide of iron) called *geru*, to deter white-ants from attacking the trunks. Good results are reported from the Central Provinces in the treatment of white-ant-infested trees with Gondal fluid, and better results have recently been obtained with sanitary fluid.

(7) Termites are attracted by farmyard or stable manure that is dry or insufficiently rotted. The digging into the ground of improperly prepared farmyard manure is a source of white-ant attacks, the insects coming first to feed on the manure and when that is exhausted attacking the roots of plants. When termites are prevalent the greatest care should be taken to apply only well rotted manure.

Injurious Ants.

At least one species of true ant is known to attack healthy living plants both in Ceylon and India. This is the common blind brown ant,[1] of which the enormous male, as large as and similar to a wasp, comes into houses at night, attracted by the light.[2] The nest is underground, the workers behaving like termites and tunnelling through the soil to the roots of plants. We have been able to confirm the observations of

[1] 221. *Dorylus orientalis.* Westw. (Formicidæ.)

[2] See figures 54-55 of *D. labiatus.*

Mr. E. E. Green in Ceylon that the workers actually eat sound healthy plant tissue. Cauliflowers, cabbages, artichokes and other vegetables are attacked just below the soil and completely destroyed. As these ants are usually carnivorous the habit is an exception. In the case observed, the addition of a small quantity of crude oil emulsion to the irrigation water drove them away.

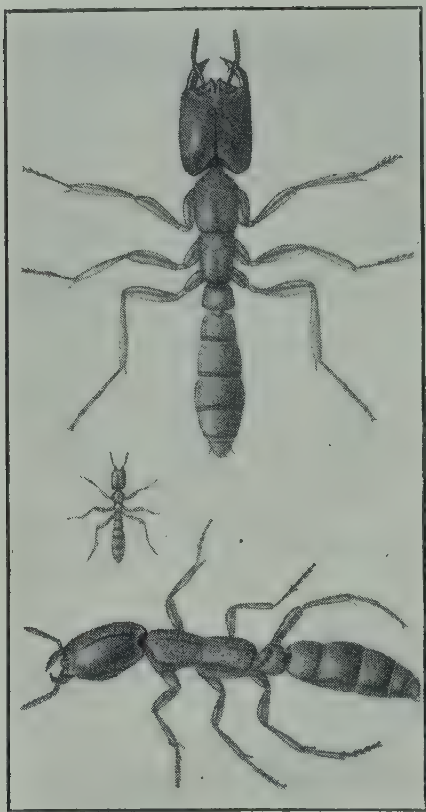

FIG. 276.
Brown Ant workers.
(Magnified and natural size.)

A second injurious ant is the harvesting ant,[1] which gathers seeds especially of kangni (*Setaria italica*) in the galleries of its nest. This is a moderately large deep brown and black ant, which makes extensive nests in the soil; in the Punjab these nests are shallow and easily dug out; other observers in India state that the nests are very deep and this depends probably upon the nature of the soil. The worker ants bring the seeds one by one to the nest and store them in granaries. As much as a pint of seed may be found in a single large nest, and as the nests are in some cases numerous, a considerable quantity of seed may be destroyed. The nests are readily traced and may be dug out; the application of hot water destroys the insects, and the mere filling of the nest with water will be sufficient to drive out the occupants.

[1] 262. *Holcomyrmex scabriceps.* Mayr. (Formicidæ.)

CHAPTER XVIII.

SUCKING INSECTS.

THE distinguishing character with these insects is that they suck the juice of plants. They are *Hemiptera* marked by the presence of the suctorial proboscis. For such pests we must as a rule use special remedies.

FIG. 277.
The Sorghum Bug. (*Magnified.*)

Sucking insects include practically two large classes with intermediates; there are the active *Plant Bugs* which run about the plants and suck any part that attracts them; there are also the *Scale Insects* and other "Plant Parasites", which fix themselves down and never move. The former may leave no trace of their work, simply inserting their proboscis and feeding where they will; the latter are fixed and local. Between the two are the *plant lice,* which behave as the plant parasites but share the mobility of the plant bugs. This is a fundamental distinction when one regards the insects from the economic point of view and entirely alters the character of the treatment possible for each form of disease.

Plant Bugs

Among the occasional pests of Indian crops, the plant bugs are of common occurrence, doing in the aggregate a considerable amount of harm which very rarely becomes apparent. These insects live upon plants, sucking the juice

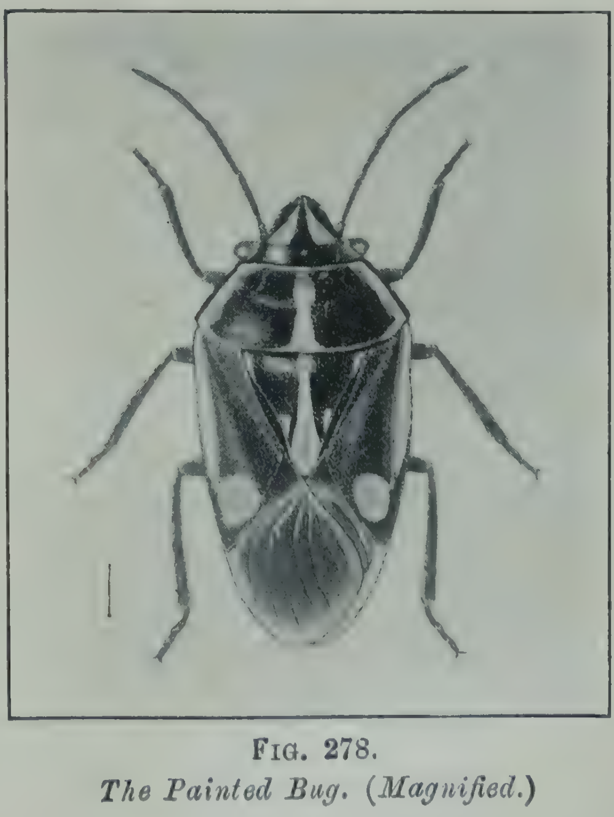

FIG. 278.
The Painted Bug. (*Magnified.*)

from the leaves, the stem or the fruit; many species are known in jungles and waste lands, a few of which attack crops or garden plants. The Red Bug and the Dusky Bug of cotton (page 104), the Maize Fly and Cane Fly (page 134), and the Rice Bug (page 116) are examples of plant bugs which attack only specific crops and are special pests. A number of other species attack crops occasionally, though feeding habitually upon wild plants and only entering the crops when they have become exceptionally abundant.

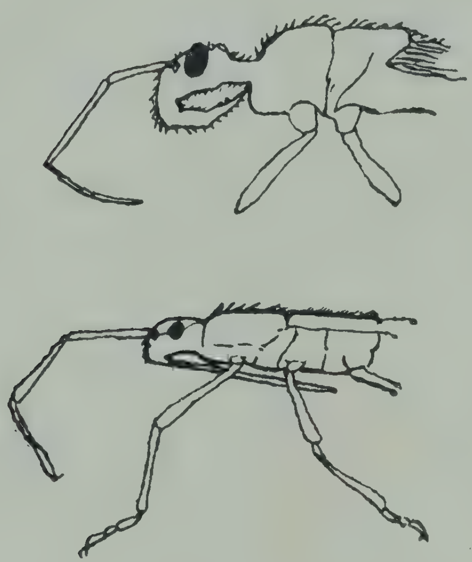

FIG. 279.
Sucking mouth-parts of Hemiptera; the upper one has the curved beak of the predaceous, the lower that of the herbivorous bugs.

The life history varies with the species. Eggs are laid on the plant or on the ground, the little bugs that hatch resembling their parents in general form. Bug eggs are easily recognisable, being laid in little clusters on the leaves in many cases; the eggs are often cylindrical with neat lids that open when the bugs emerge. There are a number of moults, the wings appearing at the penultimate one. The bug extracts food from the plants by means of the beak, a slender tube provided with sharp lancet-like instruments; the end of the tube is applied to the plant; the lancets work up and down till they pierce the tissues and the sap is withdrawn by suction. After feeding, the bug withdraws the lancets and moves on.

Plant bugs form a large group with very varied habits and very diverse form. They are in all cases recognisable by the beak, a straight sharp tube which extends from the head along the lower side of the body.

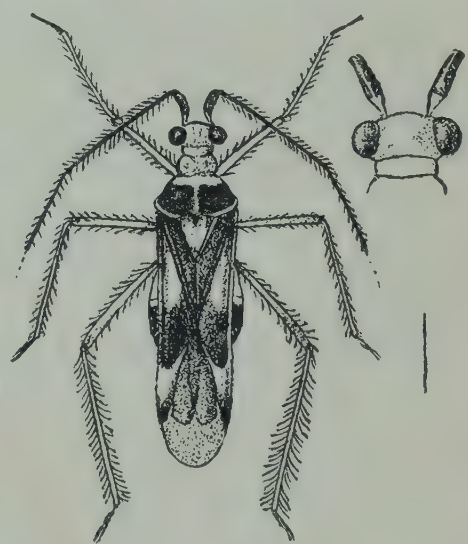

FIG. 280.
The Cinchona Bug, almost identical with the Betel Vine Bug. (Magnified.) (From Distant.)

Other bugs that feed upon the juice of insects are predaceous, having a poisonous bite. One of the larger predaceous bugs comes into houses at night, attracted by lights, and if handled, inflicts a very painful bite. These predaceous bugs can generally be known at once by the form of the beak, which is short and curved; whilst in the plant bugs it is long and extends straight between the legs (see fig. 279). This is not invariable as some of the true plant bugs

are predaceous on occasion, but practically any bug with a curved beak is predaceous and therefore useful. It is unnecessary to mention a large number of species of bugs, the examples dealt with above being sufficient. The mosquito blight of tea is perhaps the best known in India. Coffee berries in the Nilgiris are sucked by a small brightly coloured plant bug [1] which is common also in Ceylon. The potato plant is the favourite food-plant of the Green Bug,[2] a widely distributed pest (fig. 190, page 168). Mustard and rape are the food-plants of the Painted Bug,[3] a small brightly coloured species very abundant in the plains (fig. 278). Maize, sorghum and millets are found to harbour a bug,[4] coloured in grey, brown and black, which infests the heads but does no harm (fig. 277). A closely similar species [5] with sharp spines on the edges of the thorax is common in the crops but is apparently wholly predaceous.

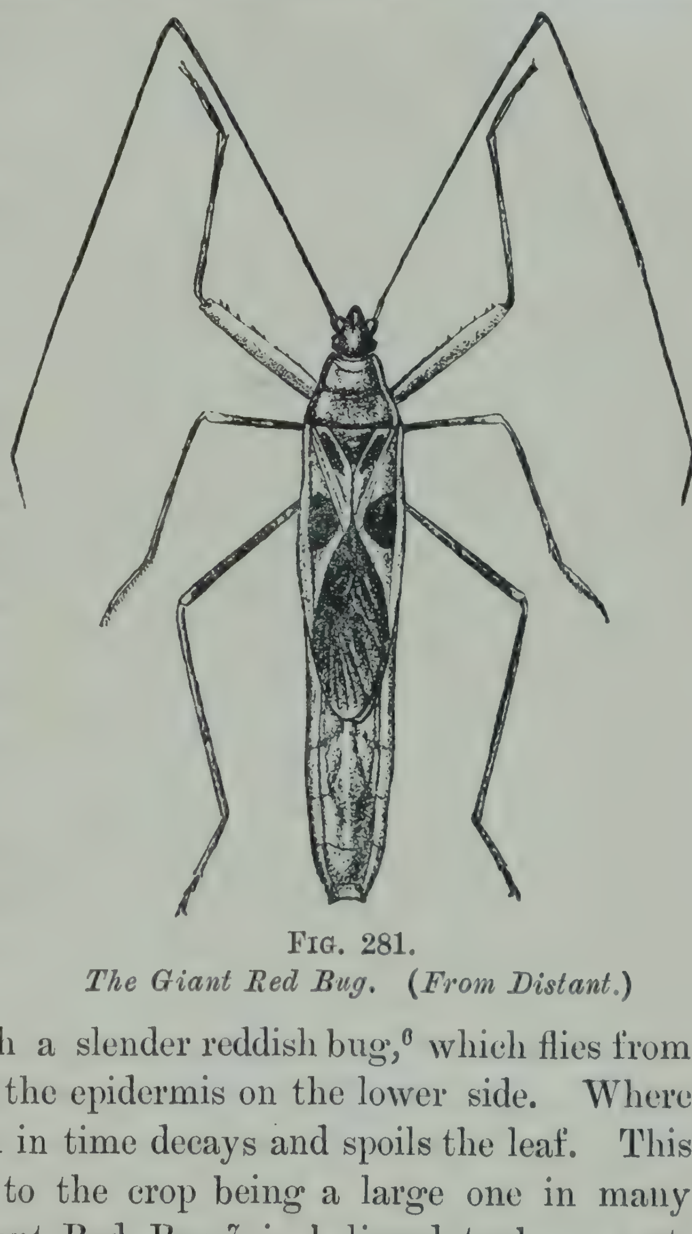

FIG. 281.
The Giant Red Bug. (*From Distant.*)

The betel vine is infested with a slender reddish bug,[6] which flies from leaf to leaf and feeds by sucking the epidermis on the lower side. Where it sucks, a spot is formed which in time decays and spoils the leaf. This is a more serious pest, the loss to the crop being a large one in many cases. In Lower Bengal the Giant Red Bug [7] is believed to be a pest, probably on account of its very vivid colouring, but it is not known seriously to injure any crop.

A small greenish bug is commonly found upon the heads of the cholam (*sorghum*) and cumbu (*bajra*) in South India, sucking the milky grain (fig. 282). This is not an unusual form of injury, but it is rarely reported; in parts of South India it appears to be particularly common and the

[1] 207. *Antestia cruciata.* F. (Pentatomidæ.)
[2] 223. *Nezara viridula.* L. (Pentatomidæ.)
[3] 169. *Bagrada picta.* F. (Pentatomidæ.)
[4] 224. *Agonoscelis nubila.* F. (Pentatomidæ.)
[5] G. 116. *Canthecona furcellata.* Wolff. (Pentatomidæ.)
[6] 25. *Disphinctus* sp. (Capsidæ.)
[7] 1236. *Lohita grandis.* Gr. (Pyrrhocoridæ.)

bug is a somewhat serious occasional pest.[1] Another small dusky bug[2] is reported as a pest; this is closely allied to the notorious chinch bug of the United States, but there is no accurate record of its being a serious pest in India (fig. 284). A peculiar form of injury is caused by bugs which gather on the threshing floor and suck out the seeds of sesamum and other oil crops. The principal of these bugs is a small brownish insect,[3] common in the plains; it also attacks the seed on the growing plant and may be reckoned a casual pest to oil seeds in general (fig. 285).

FIG. 282.
The Cholam Bug. (Magnified.)

Other species have been recorded as injuring crops but cannot probably rank as pests in the broadest sense of the word.

The method of capturing the Red Cotton Bug (page 106) is applicable to many other bugs, which are easily collected by hand in the crops. If this is done in good time, no harm results and it is only rarely, when favourable conditions occur and nothing is done to check them, that bugs become destructively numerous. The betel vine grower catches his pest by hand, crushing it in a folded leaf of the plant. In the case of the Painted Bug and similar insects, the eggs are very easily collected and destroyed, and the pest would be most simply checked in this manner if the cultivator was familiar with them.

FIG. 283.
Another Grain-Sucking Bug. (Magnified.) (From Distant.)

In special cases it may be possible to use contact poisons, as when the heads of cholam are dipped or wetted in kerosene emulsion to

[1] 222. *Calocoris angustatus.* Leth. (Capsidæ.)
[2] *Blissus gibbus.* F. (Lygæidæ.)
[3] *Aphanus sordidus.* F. (Lygæidæ.)

prevent the bugs from gathering in them to eat the young grain. As a rule no insecticides can be used against these hard bugs at a sufficient strength to kill them, but only to drive them away or to make the plant distasteful to them.

Green Fly and Plant Lice (Aphidæ).

Plants are often found to be covered with colonies of tiny black or yellow insects, which cluster thickly on the leaves and twigs. Such plants, as a rule, have an unhealthy appearance and the lower leaves are covered with a sticky substance. This appearance of the leaf and plant is a symptom of one of the sucking insects described here; if the little insects move about, are not covered with a scaly covering and have the two little tubes projecting from the abdomen (see fig. 286), then it is safe to conclude that the insects are plant lice, also known as green fly or aphides. The insects are small, the largest not more than one-tenth of an inch long; each has three pairs of legs, a sharp suctorial beak, eyes, and feelers; there are also the two short tubes or knobs which project from the upper surface of the abdomen. Some are winged, others unwinged.

FIG. 284.
The Indian Chinch Bug. Immature form. (*Magnified.*) (*From Distant.*)

The life history of these insects varies very much according to locality, climate, etc. As a rule, the colonies are composed only of females which may be winged or unwinged, and all of which produce young alive, all females. Males are not found and the young attain maturity in a few days from birth, when they too bring forth young. The rate of reproduction is thus enormous, the colony increasing very rapidly in number. When the colony is small, it is found that the females are unwinged; later on winged individuals appear, the wings forming gradually as they do in other insects which have no metamorphosis. These winged females fly from plant to plant spreading the colony over a large area; wherever they settle down they found a fresh colony and the rate of multiplication and spread becomes enormous.

FIG. 285.
The Til-seed Bug. (*Magnified.*) (*From Distant.*)

This occurs typically in the species which are found attacking crop in India, and it is probable that at particular seasons of the year, males are produced and a sexual generation found. The life history of no

Indian species has been traced throughout the year, but on analogy with species elsewhere, there is probably an alternate generation on another

FIG. 286.
Winged and Wingless Plant Lice. (Magnified twelve times.)

food-plant. These insects injure plants by the enormous quantity of sap they extract. They also excrete a sweet liquid which, falling on the leaves below, makes them sticky and shiny; this appearance on the plant is generally familiar in India. Ants and other insects are fond of this liquid and come to the plants to obtain it; ants obtain it direct from the plant lice and it is well known that some ants use plant lice as we do cows, not only "milking" them but preparing shelters for them and caring for them.

Plant lice attack plants more often in cloudy weather. This is due partly to the fact that the winged insects fly in cloudy weather and so spread, and partly to the more unhealthy condition of the plant. As a rule, too, plant lice thrive in damp weather or when a moist wind is blowing; a dry hot wind often kills them so that their occurrence on the crops is largely a matter of climatic conditions. These conditions are not as yet fully understood and plant lice sometimes thrive best in the absence of rain. Not only climate, but the condition of the plant affect the occurrence of plant lice and the latter is a subject that has not been investigated. Plant lice attack several crops in India and are

destructive to some of them. The Cotton Aphis is dealt with above (page 110). Other species attack tur and leguminous plants,[1] mustard, rape and cruciferous crops,[2] sorghum and maize, wheat, indigo, etc. All are destructive when circumstances are favourable, and a long spell of cloudy weather will bring them out upon the crops.

An important feature in these attacks is the vigour of the plant ; a strong healthy plant resists attack and is less liable to it; an exotic plant, not fully acclimatised, suffers more than a hardy indigenous variety. Crops growing under bad conditions, with too much moisture or on exhausted land, suffer far more than the same plants growing under good conditions. As a rule, an attack of plant lice is produced by these causes and only a removal of them effects a cure.

The artificial remedy for plant lice is spraying, a perfectly efficient and simple business which should be carried out on experimental farms. It is not at present possible to introduce it into general use and will never be, until the cultivator is able to watch for his pests and check them at the start. A field once thoroughly infested with aphis can be cured only by a considerable expenditure in labour and insecticides, an expenditure exceeding two rupees an acre under the best possible conditions. The actual destruction of the first colonies of the plant lice by spraying is a matter principally of watchfulness, the necessary materials costing but very little ; but this requires an intelligent foresight and much care in finding and thoroughly destroying the first colonies. As a rule nothing can be done to check plant lice because the matter is not taken in time ; the adverse climatic conditions cannot be altered ; the vigour of the plant must be maintained in every possible way and so far as possible the first colonies of plant lice destroyed.

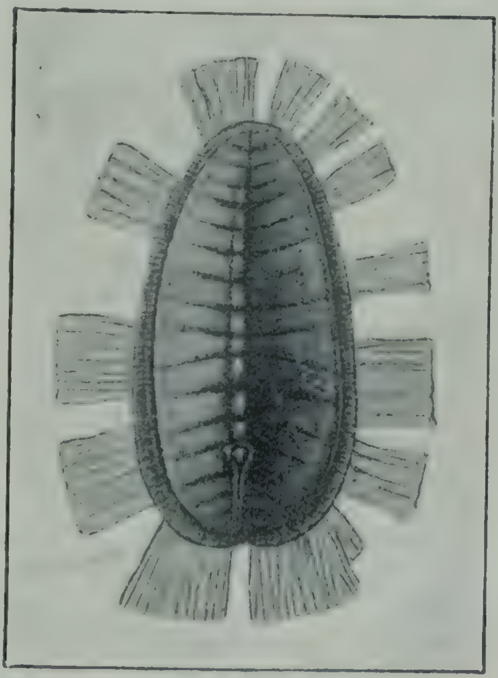

FIG. 287.
The scale enclosing the young Mealy Wing. (Much magnified.)

Further investigation of plant lice is required to discover their alternative food-plants and generations, as they live only for part of the year on crops and probably have wild food-plants at other seasons ; it may be possible to check them by the destruction of these food-plants, this being done at a time when the attacked crop is not growing. Plant

[1] 83. *Aphis cardui.* Linn. (Aphidæ.)
[2] 162. *Aphis brassicæ.* Linn. (Aphidæ.)

lice have many enemies, which cause an enormous diminution in their numbers. These insects are dealt with elsewhere (page 273). If we could be sure that these enemies would attack the plant lice in time, we could naturally check nearly every outbreak, but at present this is not possible. These beneficial insects should be generally familiar and on no account be destroyed.

The Mealy Wings (Aleurodidæ).

Small scale-like insects are frequently found upon plants, with small whitish flying insects which look like very minute moths. These are the insects known as mealy wings, generally classed with the scale insects and mealy bugs, from which they are however quite distinct. The young of both are much alike in general appearance, but if winged insects are found in any numbers, the species is almost certain to belong to this group. A number of species are known in India upon a variety of plants, and though not common as pests they are found and sent in for examination occasionally.

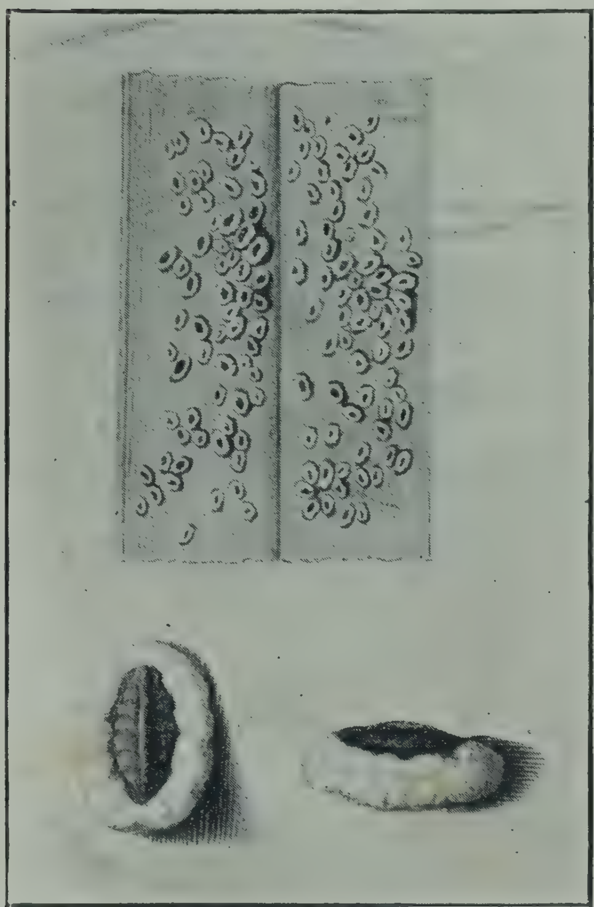

Fig. 288.
Young Mealy Wings in scales.

Life History.—The female lays eggs upon the plant, the eggs usually enveloped in white cottony material which she places upon the leaf. These eggs hatch to small insects which walk about the plant. Each insect is very minute, scarcely visible to the naked eye ; it has a beak which it pushes into the tissues of the plant in order to extract the sap. Having found a good place it settles down and remains there until it emerges as a flying insect. Each insect when settled down has the appearance of a small scale, not more than one-tenth of an inch long ; often they are black or dark-coloured with a fringe of white and some white down over them. Others are brown or green, or are transparent and not easily seen upon the plant. They remain fixed on the plant, often in large numbers together. The juice of the plant is sucked out and the plant itself weakened. The period during which they live thus varies

according to season, and other conditions. When nearly full grown the insect rests, entering into a condition similar to that of a butterfly chrysalis. When this is completed, a tiny white insect emerges, with two pairs of wings large for its size, which give it the appearance of a tiny moth. Both sexes are winged; this and the fact that they have four wings distinguishes them from the very similar scale insects (*Coccidæ*) in which the male alone has two wings, the female none.

Having mated, the female lays eggs and dies.

Mealy wings are found upon a variety of plants and there are many species in India. Two attack orange, one attacks sugarcane, another attacks rose; a common one in Western India attacks the mango, the leaves being covered with the small black scales. Another is found on castor, and many wild plants are infested. The group is not fully known yet, and, though not as important as the scale insects, many species remain to be discovered.

If the insects have not yet reached the flying stage, they may in some cases be destroyed by cutting off the infested part and burning it. No other treatment is possible except spraying insecticides on to them to kill them. This is quite simple if the necessary appliances are available and is described elsewhere (Chapter VII). The insecticides best for

FIG. 289.
The Clouded Mealy Wing. (Magnified six times.)

use are kerosene emulsion or rosin wash (made on the spot) or crude oil emulsion or MacDougal's Insecticide (bought ready for use). This is the simplest treatment and one that should be used in all gardens or orchards where fruit-trees or valuable plants are grown.

Black Blight.—Plants infested with these insects often have a black coating on their leaves commonly called "Black Blight"; this is often mistaken for the real disease. This black coating is the result of the work of the insects; they suck a great quantity of juice from the plant and in turn a sweet fluid (honey dew) drops from them upon the leaves below; as this dries it becomes sticky and then a mould (*Capnodium*) grows in it which, being black, gives the plant a black appearance. This mould (similar to that which comes on boots, etc., in the rains) does little harm and does not penetrate the tissues of the plant. The black must be traced to its right cause, the insects; when these are killed the mould will cease.

Scale Insects and Mealy Bugs (Coccidæ).

A class of pests distinct from all others are formed by the insects generally known as Scale Insects and Mealy Bugs. They are found

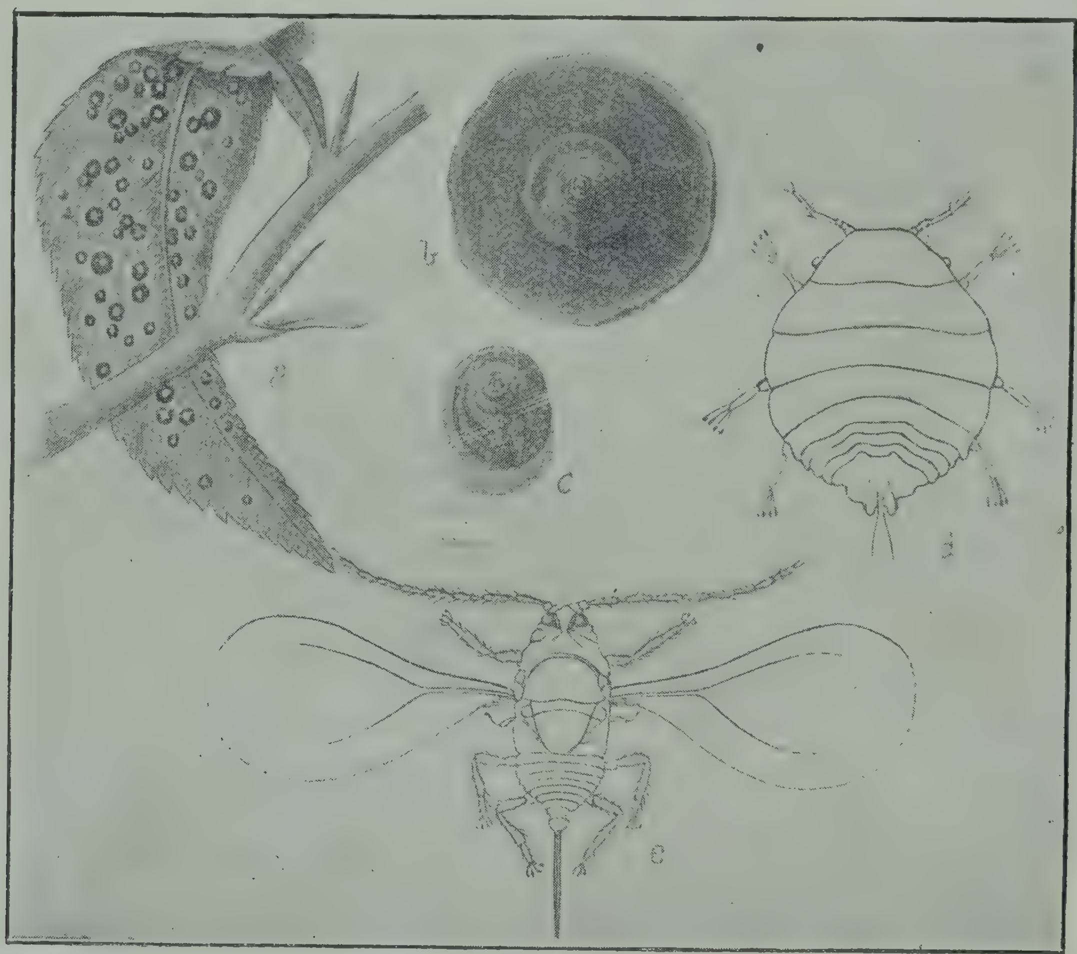

FIG. 290.
Red-spotted Scale. a, *natural size,* b, *female scale,* c, *male scale,* d, *female,* e, *male.* (*Magnified.*)

as small scale-like insects, usually thickly infesting the leaves, twigs or bark of the plants they attack. Many are covered with distinct scales, formed of special wool-like material mixed with the cast skins of the

Fig. 291.
The Black Shield Scale.

insect itself; others are covered in loose white material like cotton wool which completely envelopes them and gives them their name, mealy bugs. In some the covering takes the form of thick opaque wax, arranged in more or less regular plates. Another large division has no special covering but the skin of the upper surface is thickened. In nearly all species the size is not more than one-eighth of an inch, the insect being flattened and closely attached to the plant. No definite characters can be given by which to distinguish these insects from many others which resemble them.

Life History.—The female produces very large numbers of eggs, which may hatch at once or remain dormant for a long period. As a rule these eggs are produced slowly and accumulate under the body of the insect or in a special egg case attached to her body. The number of eggs is generally some hundreds, often thousands. The young that emerges is a small insect, flattened, with three pairs of legs hidden under the body, a long suctorial beak, and minute eyes. The young walk actively and may go for some distance in search of a fresh food-plant. Eventually each settles down, buries its beak in the tissues of the plant and feeds upon the juices. When grown larger, the skin is shed and the insect often becomes a degraded legless creature hidden under its protective covering.

The females moult once more and are then mature. Most are incapable of movement after the first moult, though the mealy bugs in particular remain active throughout life.

The male undergoes two further moults and after passing through a period of rest, emerges as a tiny two-winged fly, so small as to escape

Fig. 292.
The Black Shield Scale. (Magnified five times.)

observation. It flies in search of a female, mates and dies. Sooner or later the female produces eggs in turn and dies.

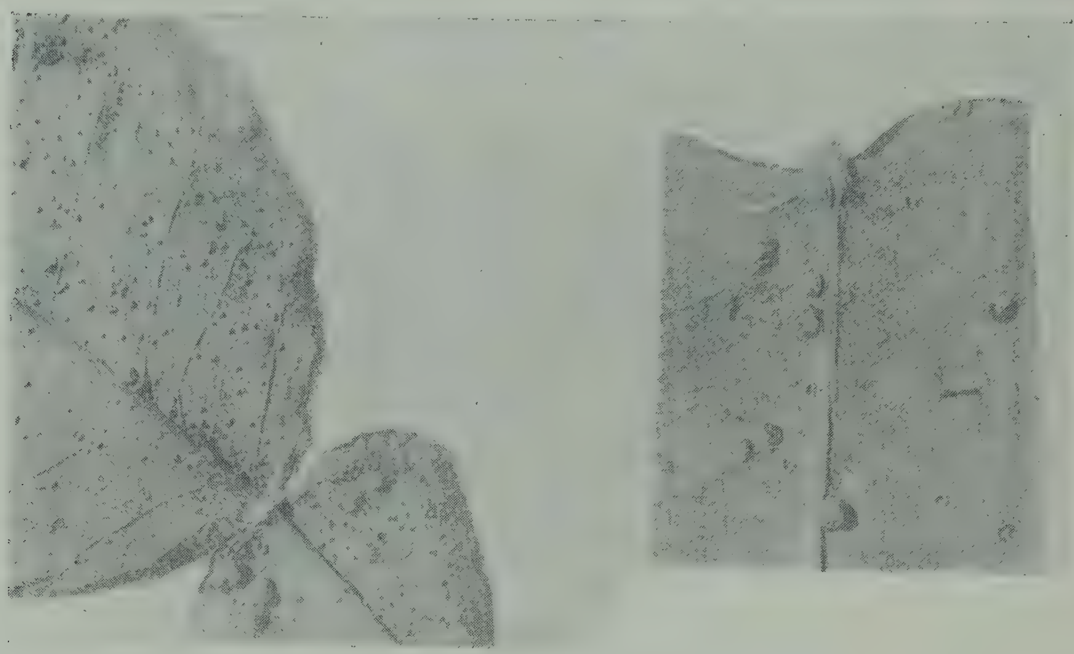

FIG. 293.
The Red-spotted Scale (left) and Black Shield Scale (right).

The whole life history may be very short or the adult female may live for many months before producing eggs. In some cases the eggs remain unhatched for a long period, awaiting favourable conditions. A curious feature of these insects is the frequent absence of males altogether; there may be none for many generations and in some species no males have yet been found. In others there are as many or more males than females.

FIG. 294.
Scale Insects on a leaf.

Food-plants.—There are many species in India which attack a variety of plants. The coffee plant suffers from the notorious Brown Bug,[1] the Green Bug [2] and a Mealy Bug.[3] The first of these is scattered almost throughout the coffee districts of Southern India, and causes a large amount of damage. It has been successfully treated by spraying, and

[1] *Lecanium hemisphæricum.* T. T. | [2] *Lecanium viride.* Gr.
[3] *Dactylopius citri.* R.

experiments show that spraying with rosin wash checks the insect and is profitable.

The Green Bug is less widely scattered but appears to be spreading from the Pulny Hills into the Nilgiris and will probably reach other districts. Both of these insects infest the twigs, sucking out the juice and gradually or quickly killing the plant. The Coffee Mealy Bug in Coorg infests the roots, specially of young plants. Experiments show that treatment with lime and sulphur, aided by an occasional application of insecticide, keeps this pest in check. Elsewhere it attacks a variety of plants, mostly garden plants.

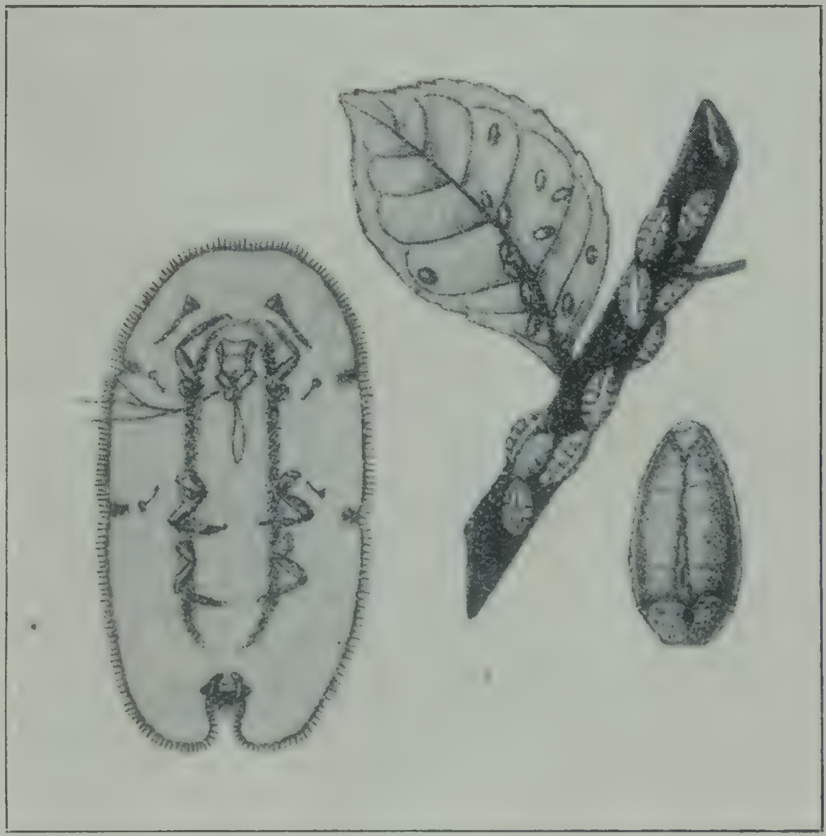

Fig. 295.
The Tea Mealy Bug.

The shade trees of coffee in Mysore are infested by the Green Mealy Scale,[1] which attacks certain trees and destroys the foliage. The black blight produced by this and allied species on coffee shade trees injures the coffee and is one of the worst features of this pest.

Another destructive species is the Red Spotted Scale,[2] a dark-coloured scale with a reddish centre; this attacks palms and is injurious to the betel palm. Sugarcane is attacked by three species,[3] the mealy bug of cane alone being widespread. It is most easily checked by care in the selection of only clean setts for planting.

Cotton is attacked by a mealy bug which lives in the top leaves of each shoot and causes the shoot to twist and form a gall; it attacks only certain indigenous varieties and is known only in Behar. Plucking the affected shoots is the simple and radical treatment for this pest.

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[1] *Pulvinaria psidii.* Mask. | [2] *Aspidiotus ficus.* Ashm.
[3] *Dactylopius sacchari.* Ckll. (Cane Mealy Bug.)
Ripersia sacchari. Gr.
Aclerda japonica. Mask.

Seed potatoes in parts of Bengal are attacked by a small mealy bug which infests them during the rains and causes them to rot. This is not a field pest but attacks the stored potatoes.

Many species are reported as attacking tea in India and others are common on fruit trees and garden plants. The latter are rarely destructive but occasionally spoil the appearance of good plants by producing "black-blight."

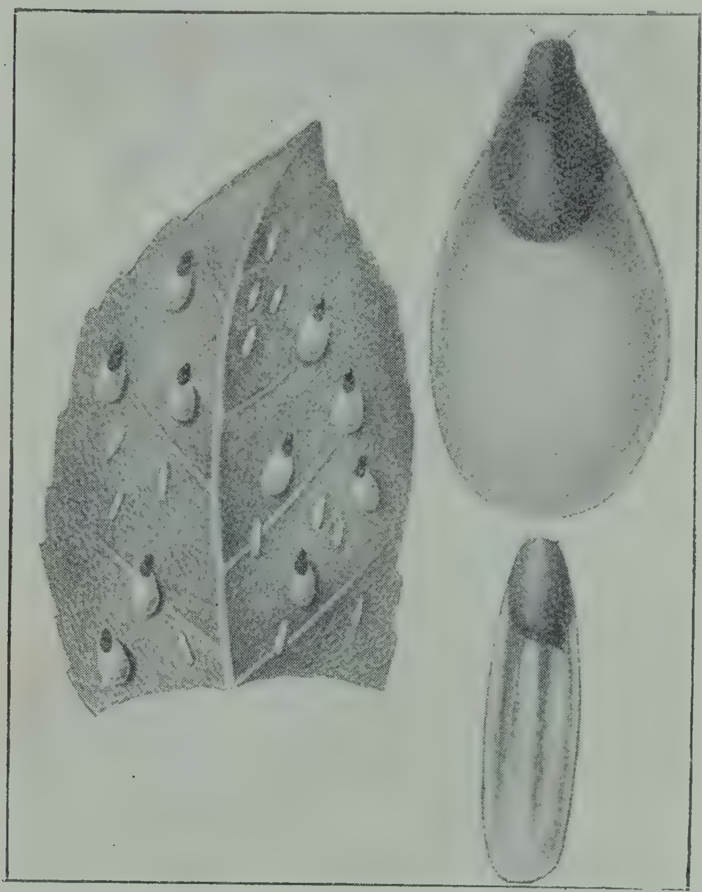

FIG. 296.
Scale Insect.
The Male Scale is the small narrow one, with one cast skin, the female larger, with two.

A destructive species[1] attacks the mulberry, infesting the ends of the growing shoots and causing them to become twisted. This pest is a serious one in mulberry plantations, unless the plants are vigorous enough to outgrow it. A striking case of mealy bug attack is found in the very large white mealy bug[2] which comes up from the soil during the cold weather and first weeks of the warm weather; immense numbers of half-grown females come up, feeding upon the bushes and trees, gradually walking up the bark until they reach the ends of the branches. They become very large, conspicuous white masses of them clustering on the end of the twigs. The males emerge from smaller scales and fly about among the branches. This is one of the largest species of mealy bug found, and the male is very large in comparison to the males of most insects of this family. It is injurious to occasional plants but is very easily killed with sanitary fluid or other contact poisons. Its food-plants are large trees and it is not injurious where it can reach these.

When scale insects are found, the simplest method is to cut off and burn the infested branch. The insects cannot escape by flying and are easily destroyed. In coffee and tea plantations it is important to watch for them and check them at once, and this is

[1] *Dactylopius bromeliæ.* Bouche. | [2] *Monophlebus spp.*

necessary also on fruit trees. The only other simple remedy is to spray them with an insecticide. Kerosene emulsion is a good mixture for the softer woolly ones; rosin wash for the hard scale-bearing species. Crude oil emulsion or McDougal's insecticide are also good mixtures and can be obtained ready made. The insecticide must be applied with some form of spraying machine, not simply thrown on with a syringe. In gardens where many plants are grown, the use of such insecticides is imperative if valuable plants are infested.

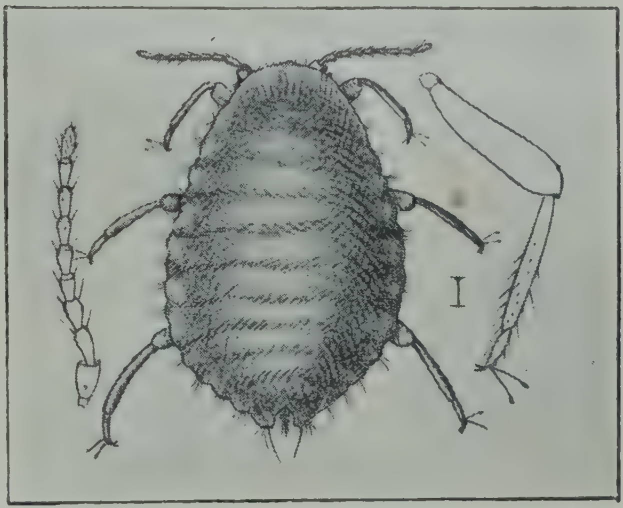

FIG. 297.
Coffee Mealy Bug. (Magnified.)

Part IV.

OTHER IMPORTANT INSECTS.

CHAPTER XIX.

INSECTS INFESTING GRAIN.

A NUMBER of destructive insects feed upon dry grain flour, seeds, pulse and other dry food-stuffs, occurring in great quantity wherever these are stored in bulk and working a very large aggregate amount of destruction. They are common also throughout the villages of India, where special means of storage are used to exclude them, not always successfully.

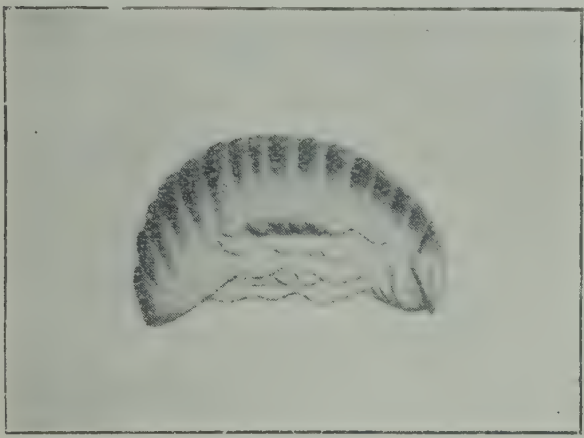

FIG. 298.
Rice Weevil Grub. (*Magnified.*)

They belong to two orders, the beetles and the moths, the former being the more abundant. No extensive investigation has ever been conducted into these pests in India and the available information has been gleaned from reports or discovered in chance investigation.

The Rice Weevil.[1]

A small dark-coloured weevil, about one-eighth of an inch long with a prominent curved snout. It lays its eggs on rice, corn, wheat and other grains, in little indentations made with its jaws; the larvæ eat into the grain, become full grown there and emerge as weevils after passing through the pupa stage. The insect is apparently abundant everywhere in India, and is known throughout the warmer parts of the world. It is injurious to nearly all varieties of grain.

FIG. 299.
Rice Weevil Pupa. (*Magnified.*)

The Wheat Beetle.[2]

The Wheat Beetle has been found attacking wheat and other stored produce in India, its larvæ

[1] *Calandra oryzæ.* L. (Curculionidæ.) | [2] *Trogosita mauritanica.* L. (Trogositidæ.)

being destructive, though not living actually in the grain. The beetle is believed to be carnivorous, attacking other insects found in the granary.

Fig. 300.
The Rice Weevil. (Magnified.)

The "Sawtooth Beetle"[1] is so called from the toothed appearance of the prothorax. It is found in all stages, the larvæ running actively in the grain, hiding when exposed to light. It has been recorded as destructive to sorghum and other stored produce. This is also a cosmopolitan pest. The Biscuit Beetle,[2] a minute brown insect found attacking biscuits in Calcutta, is closely related to the last species and belongs to a cosmopolitan genus. The Leather Beetle[3] is a cosmopolitan insect enemy of leather and leather goods; it attacks silkworm cocoons in India and is destructive to stored pupæ of the silkworm moth. Its larvæ are very hairy, distinct in appearance from those of the preceding beetles.

Fig. 301.
Rice Weevil. (Magnified.)

A dermestid[4] closely allied to the last is reported from India in wheat. This or the last is the insect found in grain in Gujarat, where it is believed to be of use in checking other grain

[1] *Silvanus surinamensis.* L. (Cucujidæ.)
[2] *Læmophloeus pusillus.* F. (Cucujidæ.)
[3] *Dermestes vulpinus.* F. (Dermestidæ.)
[4] *Æthriostoma undulata.* Motsch. (Dermestidæ.)

insects, notably the Red Grain Beetle. This belief is so firmly held that the dermestid is introduced in the grain infested with insects as a check on them.

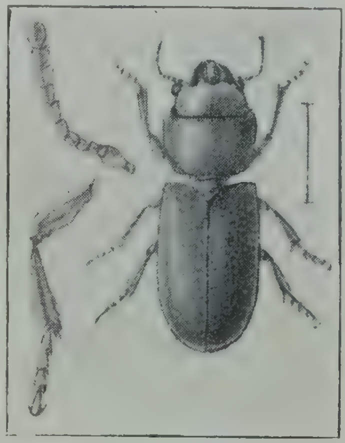

Fig. 302.
The Wheat Beetle. (*Magnified.*)

The Cheroot Beetle[1] is a small active insect, whose larvæ are found principally in cheroots and tobacco, but also in opium, saffron, ginger, etc. It is closely allied to a similar insect now almost cosmopolitan, which attacks tobacco in all its forms elsewhere.

The two Red Grain Beetles[2] are very common in India, feeding upon grain, biscuits, and having a great liking for dried insects. Both are cosmopolitan and they are distinguishable only with some care.

Fig. 303.
The Biscuit Beetle.

The Areca Nut Weevil[3] is a widely spread insect which attacks the areca nuts and is also a common insect in old dry cotton bolls; its larvæ live in the seeds of old cotton bolls left on the plants, and immense numbers can be bred from them. Probably the insect has many other foods. Finally the notorious "Cask Weevil" may be mentioned, a species found to attack beer casks in India, not from a taste for the contents but for the wood which is its natural food. This species is the Sugarcane Weevil[4] of the West Indies, an insect attacking diseased canes and at one time believed to do much harm.

Fig. 304.
The Saw Toothed Grain Beetle. Larva in the middle; pupa on the right. (*Magnified.*)

In addition to the above species, there is a distinct family which attacks pulse. These beetles lay their eggs on the dried pulse, small yellow eggs very closely resembling certain scale

[1] *Lasioderma testaceum.* Duft. (Ptinidæ.)
[2] *Tribolium ferrugineum.* F. and T. *Confusum.* Dw. (Tenebrionidæ.)
[3] *Aræcerus fasciculatus.* Deg. (Anthribidæ.)
[4] *Xyleborus perforans.* Woll. (Scolytidæ.)

insects. The grub eats into the seeds, making a neat cavity which just holds the insect, and lives there until pupation when it prepares an exit for the

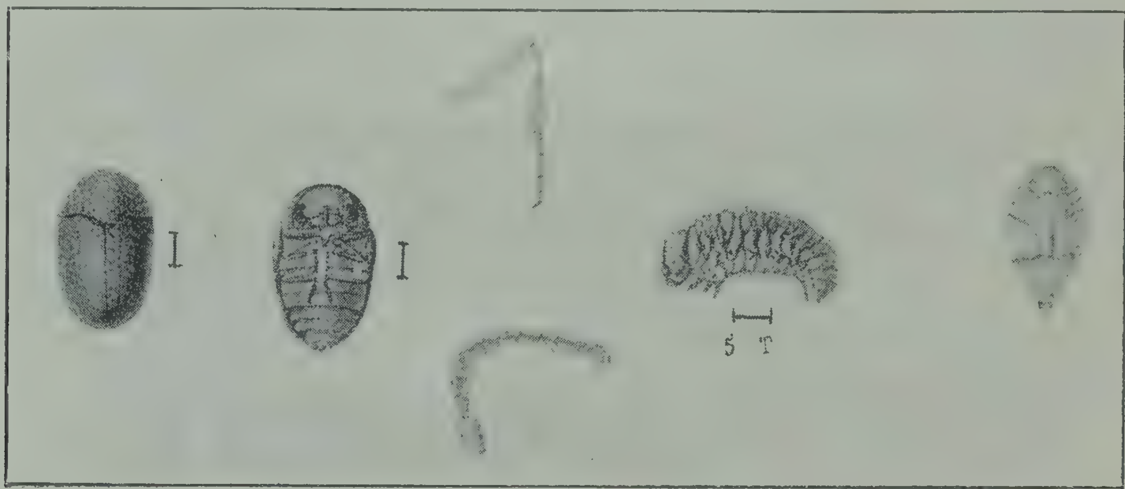

FIG. 305.
The Cheroot Beetle. Pupa on the right; Larva in the middle. (Magnified.)

beetle by cutting a neat round disc, not cutting it through but leaving it so that the beetle can escape easily (fig. 308). These pulse beetles are of peculiar form and easily recognisable. They attack the common pulses

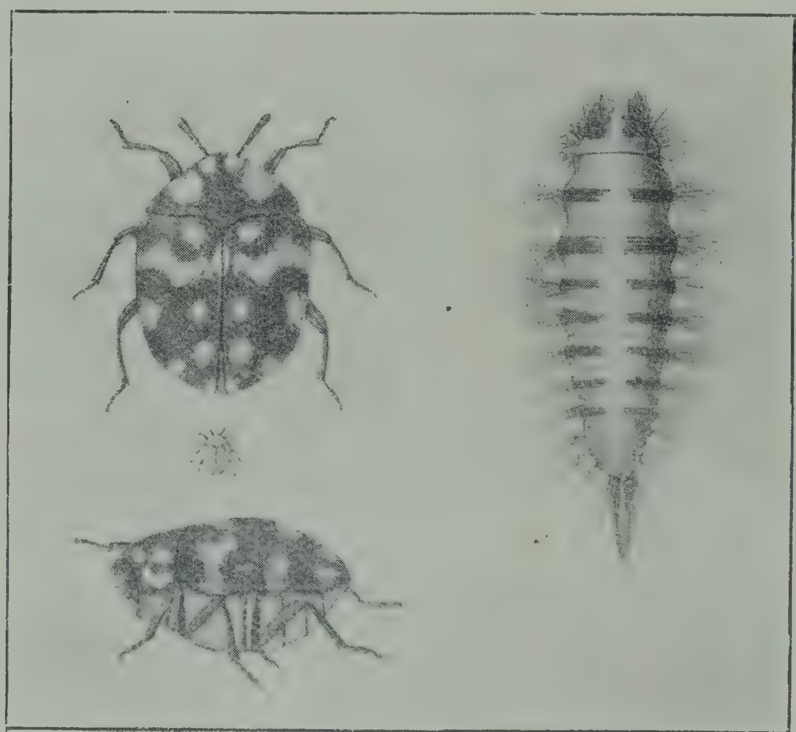

FIG. 306.
Larva and imago of common Leather Beetle. (Magnified.)

of India in the dried condition and have not been found upon the growing plant, as they are elsewhere. At least two species[1] are common in

[1] *Bruchus chinensis.* L. (Bruchidæ.); and *Bruchus emarginatus.* All. (Bruchidæ.)

pulse and a third is recorded in tamarinds.[1] Several wild species have been found and wild leguminous plants are probably extensively attacked.

Fig. 307.
The Red Beetle. (Magnified.)

Moths are also injurious to grain, flour and similar products, and it is

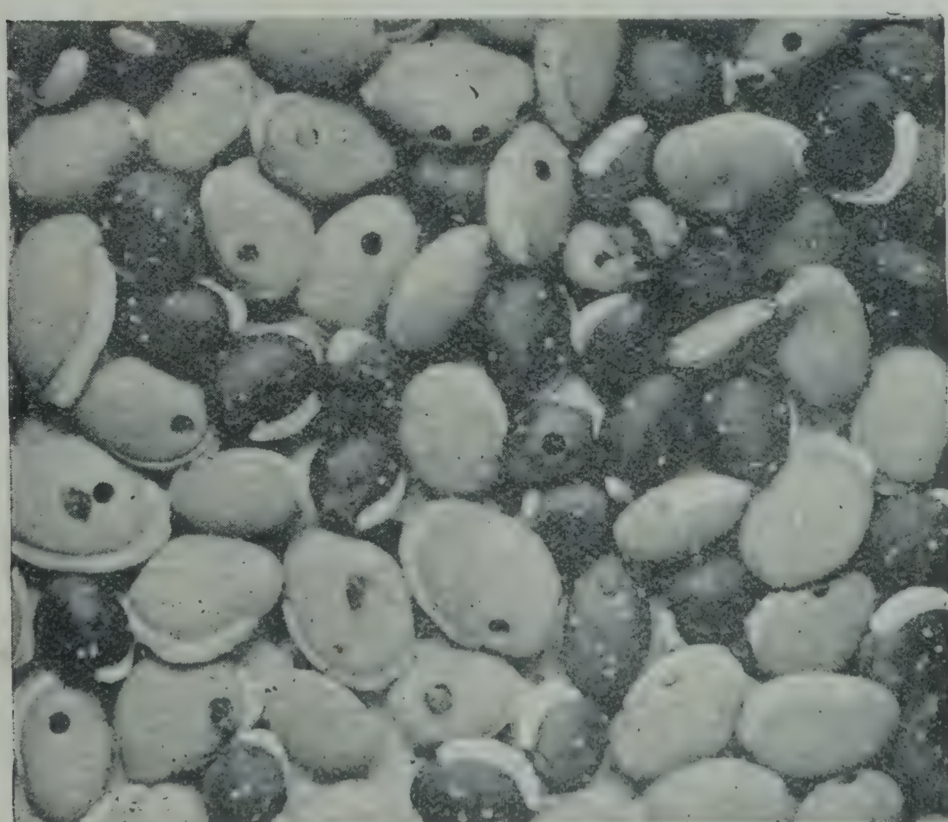

Fig. 308.
Beans attacked by beetles, showing the holes of exit made by the beetles and the discs cut in the skin.

uncertain as yet which species are concerned. One small moth, known as

[1] *Caryoborus gonagra.* F. (Bruchidæ.)

the Anjoumois[1] Grain Moth, has been found attacking corn. This moth lays its eggs on the grain, the larvæ eating straight in and spending their larval life within. The moth is a small handsome insect, found flying in granaries and ware-houses. At least one other[2] moth is common in India on flour and meal. The larva of this species is found making silken webbing to which the meal becomes attached, the whole forming galleries in which the larva lives. These peculiar webbed masses of meal or flour are characteristic and easily seen.

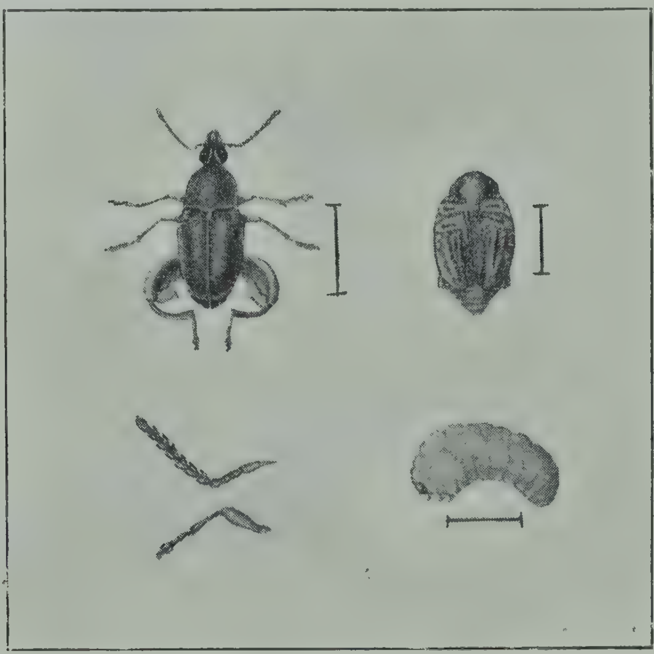

FIG. 309.
The Tamarind Beetle. Larva below; pupa on the right. (Magnified.)

Treatment.

Food-grains, dried food-stuffs and seeds of all kinds are liable to the attacks of these insects and are sure to be infested sooner or later if precautions are not taken. The following are the principal precautions which should be adopted in the preservation of all seeds, grain and food-stuffs from insects.

(1) Before placing seeds in a godown or a room of any description, make sure that it is clean, and that there is no refuse or spilt grain in which the insects could breed or hide.

(2) Never store seeds that are already infested with insects or that could be harbouring grain beetles; one beetle is sufficient to infect the seeds, and the increase in a few generations of beetles will be sufficient to destroy the seeds.

(3) Keep all grain, seeds, etc., in tight vessels. It is useless to store grain in an open receptacle, exposed to weevils. Sooner or later insects will come to the grain and lay eggs

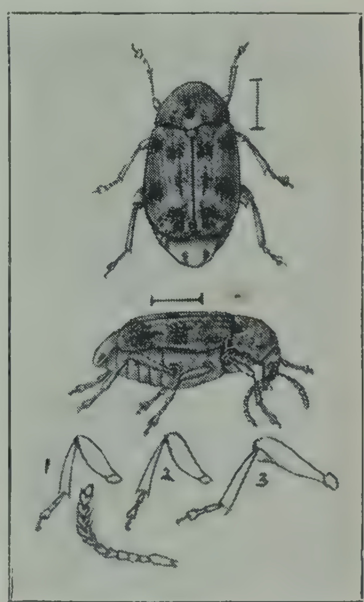

FIG. 310.
The large Pulse Beetle. (Magnified.)

[1] *Gelechia cerealella.* Oliv. (Tinelidæ.) | [2] *Ephestia cahiritella.* Oliv. (Pyralidæ.)

there. Either the whole godown must be insect-proof or the seeds must be kept in tight vessels. A bamboo basket is not insect-proof unless well plastered with mixed mud and cowdung. If there is anywhere a crack large enough to admit a grain weevil, the grain will be spoilt.

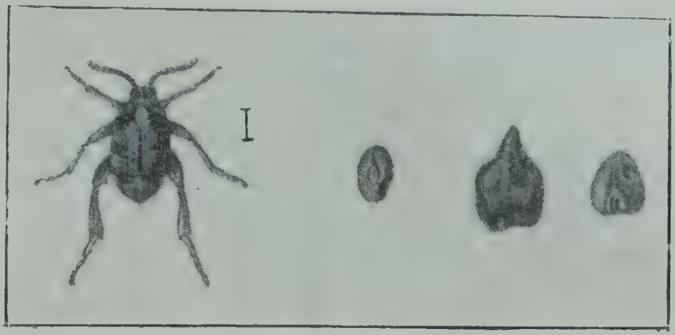

Fig. 311.
The Gram Beetle. (*Magnified.*)

(4) If stored grain becomes infested with weevils, it must be removed and cleaned. Even in an air-tight bottle or jar, weevils will live and breed if they are put in with the grain. If once the grain is infested, it must be taken out and cleaned so as to separate the good grain from the bad. Such grain before being replaced in the godown must be cleared of insects by fumigation.

Seeds and grain can be kept safely only in air-tight vessels or in insect-proof places, but this is not sufficient as the grain when put in may be infested with the eggs of grain beetles. If grain is stored, it should be examined after storing to make sure that no insects are breeding in it.

There is no treatment known that will make a seed proof against

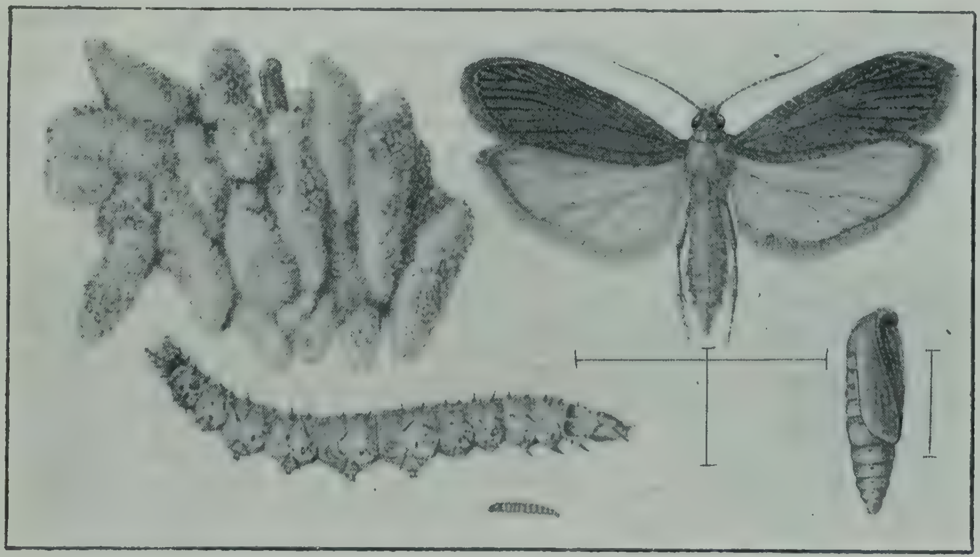

Fig. 312.
Flour Moth. Caterpillar ; cases of flour and webbing ; pupa (*on right*) ; *moth.* (*Magnified.*)

weevils and not impair its germination or food value. Seed cannot be kept unless put away free from infection and kept so. It is easier to keep seed free from insects than it is to be sure that, when put away, it is not infected; the principal difficulty with the storage of grain on any

large scale is that, when stored, it is already infected. Fumigation alone will ensure that the seed is entirely free from insects or insect eggs; fumigated seeds can be safely stored but are not safe if improperly stored; if seed is fumigated to-day, we know we can store it as being free from weevils, but if we leave it exposed for another day, it may be infested again.

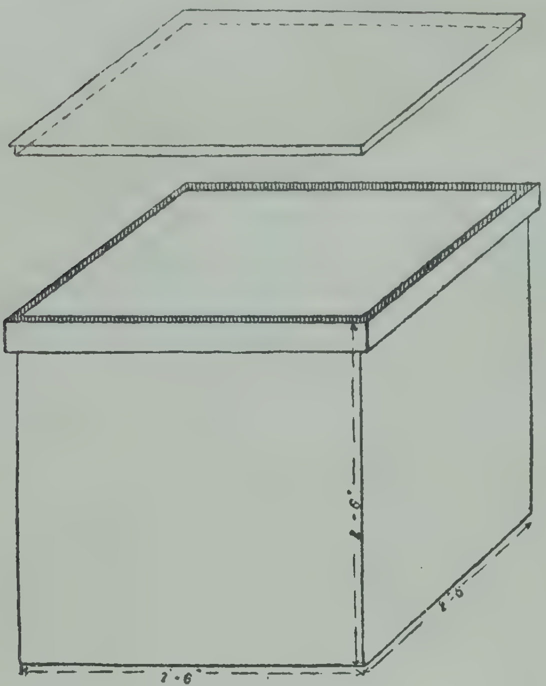

Fig. 1. Scale 1/24.

The best method of grain preservation is then to fumigate it and at once store it in insect-proof bins or jars or boxes, or in an insect-proof building. A dry underground pit is suitable, if properly insect-proof. Fumigation is a process of exposing grain, seeds, etc., to the fumes of carbon bisulphide at a proper strength for a definite period; grain exposed to the fumes of carbon bisulphide at the rate of 1 oz. per 15 cubic feet of space for 24 hours will be free from all insects; even the eggs of the insects will be killed and the grain can be removed, the fumes allowed to evaporate and the grain at once stored. Where large quantities of grain are put into a godown till it is full and there is no extra air space, we may use one to one and a half lbs. of the fluid per ton of grain. For fumigating jars or small vessels, one teaspoonful (1 drachm) of the fluid may be taken for every cubic foot of space.

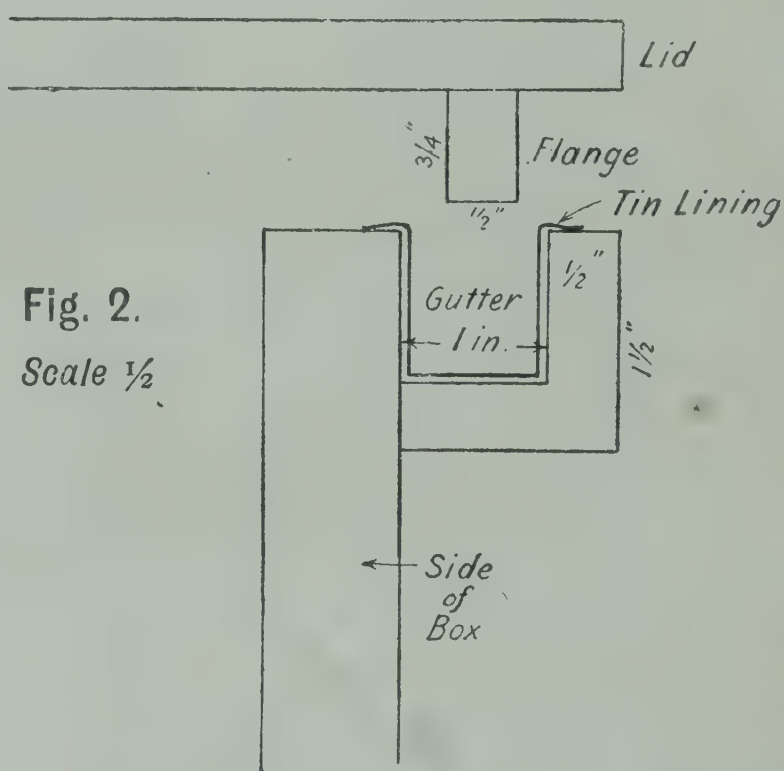

Fig. 2.
Scale ½

As carbon bisulphide is an inflammable and unpleasant liquid to handle, certain precautions must be observed:—

(1) Keep the bisulphide in stoppered (not corked) bottles under lock and key, and in a place where it will not be liable to be thrown down.

(2) When fumigating, do so in a place to which no one can get access while fumigation is proceeding.

(3) Allow no lights, no pipes, cigarettes, or any form of fire near the fumigation.

(4) Should the smell of carbon bisulphide be noticed, do not go near with a light.

(5) There is danger from the vapour only if it is mixed with air and it can be readily smelt; should the bottle leak, remove it, pour the fluid into another bottle and air the room or the place where the smell is noticed.

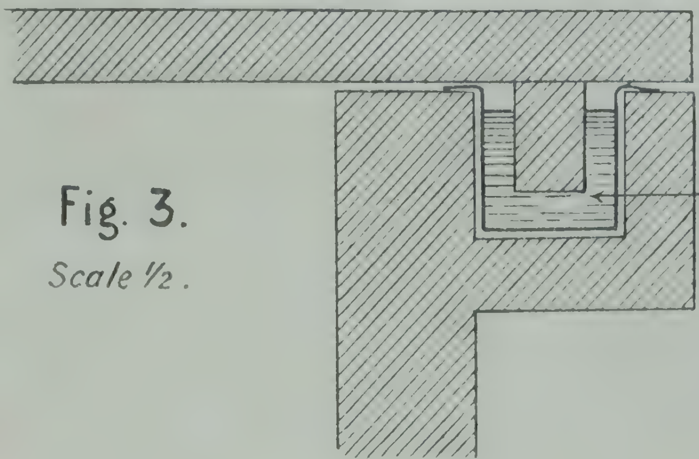

Fig. 3.
Scale ½.

(6) Do not stand a bottle of carbon bisulphide in the sunlight or in any place where it will become hot.

(7) Never take a bottle of carbon bisulphide near a fire or lighted lamp.

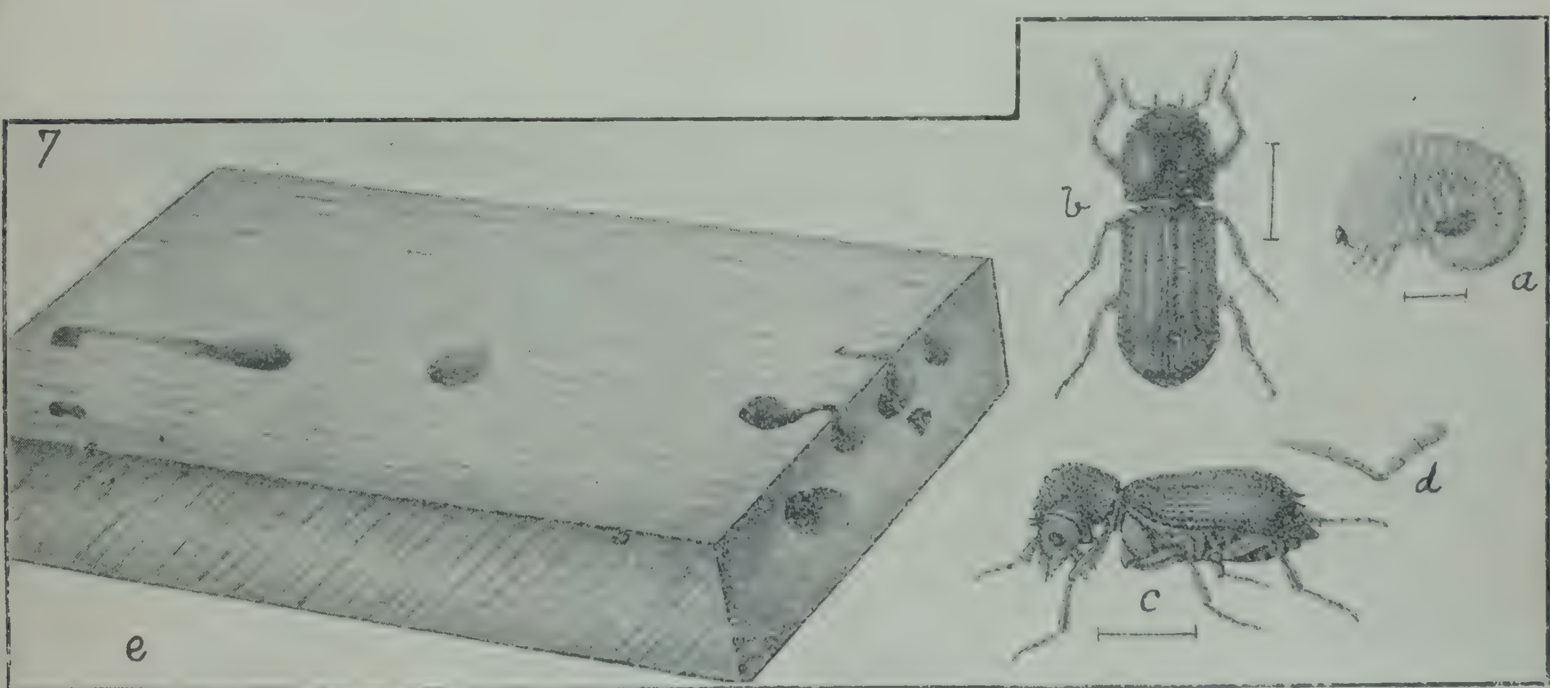

Fig. 313.
Timber-boring Beetle.
a, *larva*, b, c, *imago*, d, *antenna*, e, *timber*. (*Magnified.*)

For fumigating small quantities of seeds, the box figured above can be used, the lid of which fits into a groove filled with water which forms

an air-tight cover. Any really air-tight box, bin or vessel can be used for fumigating.

FIG. 314.
Bamboo-boring Beetle.

Provided the strength and period mentioned are not exceeded, no harm will be done to the grain either for food or for seed.

Many beetles are found boring in bamboo and dry timber. These belong chiefly to a single family of small cylindrical brown beetles, the prothorax hard and round, the head more or less concealed, the general structure fitted for life in the cylindrical tunnels made in the wood. The life history is passed in the bamboos or other food. Bamboos are soaked in water in the belief that this affords protection and makes the bamboo unpalatable to the insect. There is apparently good foundation for the belief though the precise way in which the water acts is not known. Soaking in salt water is also said to be efficacious. In general a varnished bamboo is immune from attack so long as the varnish is not worn, as is a painted one. Soaking in kerosene or painting with kerosene, followed by an application of linseed oil, is good not only for the bamboos but for furniture and all wooden articles that are attacked. This is effective when the wood is already infested. Where bamboos are to be used in the roof of a house or in any similar position not in a room or exposed, painting with a solution of arsenic is a sufficient protection.

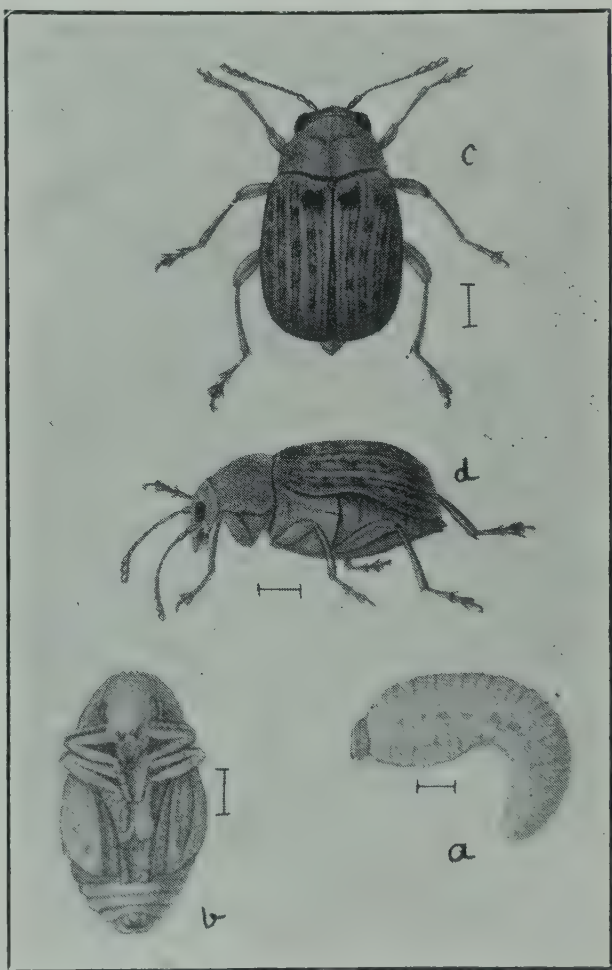

FIG. 315.
Areca Nut Weevil.
a, *larva;* b, *pupa;* c, d, *imago.* (*Magnified.*)

CHAPTER XX.

INSECTS ATTACKING CATTLE.

IN the most varied situations and under most adverse circumstances, we find insect species which have adapted their life-history, their habits and their structure to new and wholly distinct surroundings. It is therefore not surprising that we find distinct branches of insect life, wholly adapted to obtaining their food from living warm-blooded animals. Though lacking the extraordinarily well-adapted life histories of the parasitic worms, these insects are not behind others in the ingenuity of the means whereby they overcome adverse conditions : their habits have no parallel in other insects ; their structure is profoundly modified to fit them to their surroundings, and they form an extraordinarily interesting group. These insects are gathered from very diverse parts of the animal kingdom ; the bird lice are *Neuroptera ;* the quaint West African rat parasite is one of the *Orthoptera ;* the beaver parasites are *Coleoptera ;* most parasites of cattle are *Diptera.* The fleas are an abnormal group probably near to the *Diptera,* and the common bug is one of the *Hemiptera,* whilst finally the lice are abnormal erratic creatures which find no place in the larger groups of insects. It is not possible here to discuss all of these ; the fleas, flies and other creatures that affect men's welfare are beyond the scope of this book, and we are concerned solely with those insects which affect cattle and domestic animals, the fleas, house-flies, gad-flies, biting-flies, bot-flies and flesh maggots, whilst we may include the ticks which are not insects, though closely related.

Fleas.

Small laterally compressed insects, with imperceptible wings and great leaping powers, which infest warm-blooded animals. They lay eggs in dirty places, in corners, on the hair of animals, etc., from which hatch white maggots, worm-like in appearance but with distinct head, which feed on blood, animal matter, refuse, etc. These pass through a pupa stage, emerging as the imago which leads a parasitic life on mammals and birds.

The whole life-history occupies about one month at the shortest. Fleas breed particularly in dirty places frequented by animals, laying their eggs in places where animals lie down. Cleanliness is the greatest check on them. Fleas should never be allowed to breed in a house and do so only because there are domestic animals in the house which sleep in the house and are not properly cared for.

Recently the part played by the rat flea in the dissemination of plague has been discussed by Captain W. G. Liston. This article[1] should be read in full, but his conclusions briefly are that the rats, infested with fleas, get plague, infect the fleas and die; then the fleas, with the infection of plague in them, have no food and attack any available animal; should that animal be man, he gets plague from the bite of the flea. The flea in this case is simply the transmitter of the plague, and only attacks man when its proper food (the rats) have died of plague or migrated. If experience bears out this theory, the importance of the flea is immensely increased and the commencement of plague epidemics can perhaps be checked.

Ticks.

The commonest external parasites of cattle are ticks, creatures which when full grown have four pairs of legs and are allied to the mites,

Fig. 316.
The Persian Tick. (Magnified.)

spiders and other *arachnids*. They may be seen fastened to the skin of cattle and grow to a large size. Specimens have been sent in from almost every domestic animal in India, and in one case, the Persian Tick[2] was found upon human beings.

[1] Journal of the Bombay Natural History Society, XVI, 2 p. 253, April 1905.
[2] *Argas persicus.* F.

The life-history of ticks in general is a simple one. The full grown and full fed female drops from the skin on to the ground and lays a large number of eggs in a mass; these eggs hatch to small active creatures, with three pairs of legs, which run about on vegetation and are believed to feed upon the juices of plants. They fasten themselves upon the skins of animals as they pass through the vegetation and then moult, becoming fully developed with four pairs of legs. There is a large number of species, some of importance in communicating diseases to cattle and dogs. The treatment of the above

FIG. 317.
Louse. (Much magnified.)

insect and ticks is a matter generally of expert veterinary knowledge, many applications that kill the insect being harmful to the animals. General cleanliness in the stables, cattle-sheds and fowl-houses is very

important. Washing animals with various carbolic preparations is advisable and there are special cattle dips, horse and dog washes prepared and sold. For cattle and dogs, the insecticide known as crude oil emulsion is a safe and simple application, killing all forms of life in the skin and improving the condition of the coat. This emulsion mixes in water to any strength and can be worked well in; it can be left to dry on or be washed completely out of the skin with a little water. For some animals it is far better than carbolic preparations, which should not, for instance, be applied to dogs at all.

Lice.

What are generally termed lice are insects belonging to two distinct orders, the biting lice (*Neuroptera*) and the sucking lice (allied to *Hemiptera*). The former are small insects, found upon the hair of domestic animals and in the feathers of birds. They do not feed upon blood but upon hair, flakes of skin, etc. Birds rid themselves of these pests by taking dust baths, rolling in the dry dust which penetrates the feathers and is believed to check the lice. Sucking lice are small flattened insects without wings found upon the hair of pigs, goats, cattle, buffaloes and other animals. They extract the blood by means of a fine suctorial beak which is barbed, and their continued presence causes sores. These are included among the horrible creatures which infest the skins of human beings, particularly of those of uncleanly habits. No reasonably clean person who uses soap is infected by them. A peculiar species with long proboscis is said to attack the elephant, but it is not known if this occurs in India.

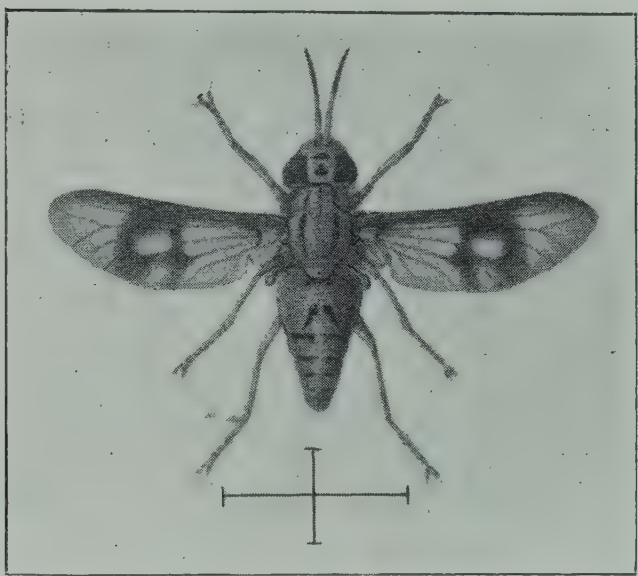

FIG. 318.
The Baluchistan Gad-Fly. (Magnified.)

Gad-Flies.

Large active flies, quick and strong on the wing, which bite cattle, horses and human beings, often drawing blood. These flies are familiar to any one who travels in the lower slopes of the hills, in

forests, and well-wooded places. They are powerful insects, with a strong sharp beak; settling on the skin, they pierce it and suck out the blood.

Many species are found upon cattle, horses and other animals, and these bite man freely. They principally breed in forests. The larva of one species has been found in India in small pools in the forests and the others probably have similar habits.

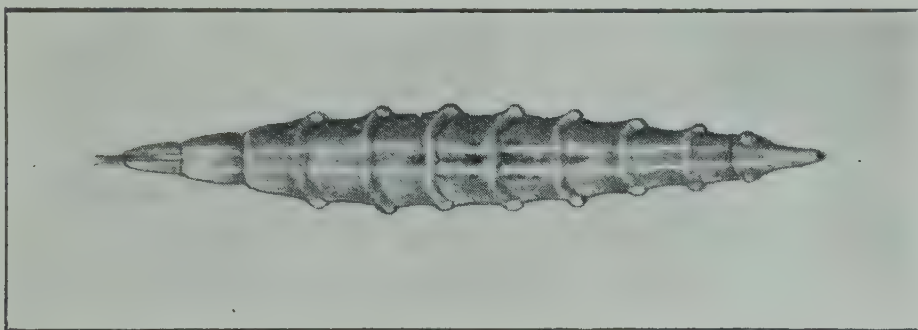

FIG. 319.
Larva of Gad-Fly, Nongpoh, Assam. (Magnified twice.)

Horse Flies.

A family of peculiar flies, much flattened, which settle on horses, cattle, dogs, etc., and live on their blood. They are characteristic in appearance, and usually marked in brown and yellow. They can be found on almost any domestic animal and on birds.

Their life-history is peculiar, in that the larva does not leave the body of the parent until full grown and is produced ready to pupate, which it does at once. The fly therefore appears to lay a pupa, from which the new fly very soon comes. This is a most striking adaptation to parasitic life as there is no larval

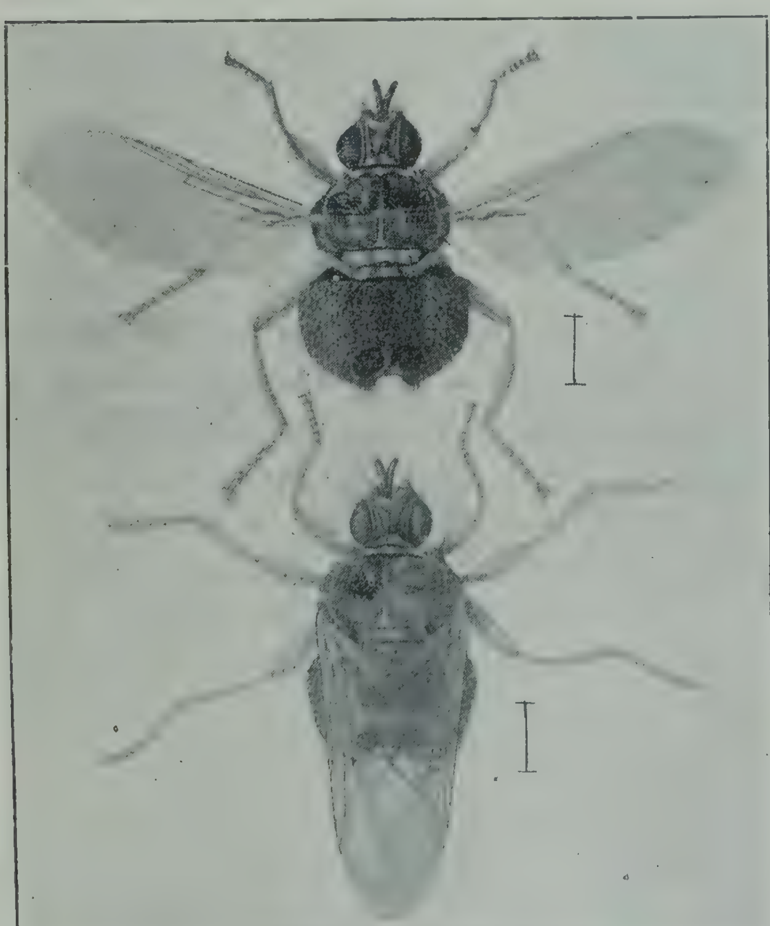

FIG. 320.
The Horse Fly. (Magnified.)

stage to provide for. The flies are in most cases very active and fly from animal to animal, but they often stay in the hair or feathers of a single host for a long period.

Bot Flies.

A number of flies do not feed themselves on the blood of cattle, but their larvæ live in their tissues. These larvæ are known as bots or warbles and have been found in India in sheep, cattle and horses. The sheep bot-fly deposits eggs or living maggots in the nostrils of the sheep, the maggots crawling up the nostrils and fixing themselves upon the mucous membrane of the nasal cavities. They cause great irritation, much mucus is produced, on which they feed and they injure the delicate nasal membranes. The maggot remains there until nearly one inch long when it loosens its hold and is thrown out on the ground; it pupates in the ground and the fly presently emerges. The remedy is to prevent the fly from laying eggs by rubbing the nostrils with tar, train oil or other sticky applications, whose smell drives off the fly and renders egg-laying impossible.

The horse bot-fly lays eggs on the hair of the mane, the shoulder, the knee or some other part within the reach of the horse's mouth. These eggs are fixed to the hair and when the maggot hatches, it is licked off by the horse and swallowed; it then attaches itself to the membrane by means of the hooks in the mouth and feeds by suction. When full fed it passes through the alimentary canal to the ground where it transforms to the pupa and emerges as a fly.

The cattle bot or warble-fly is found as a larva under the skin of cattle, buried head downwards in the tissues with the hind end of the body towards the opening in the skin; air is obtained through this opening and drawn in by the two large spiracles on the last segment. The maggot feeds upon the putrid matter produced in the sore; when full grown it forces itself back through the opening in the skin and falls to the ground, where it pupates. This insect causes a large amount of damage to the hides, warbled hides being of very inferior value. The condition of the infested animal is also bad. Treatment for this and for other bot maggots is a veterinary matter, which should have the attention of a qualified veterinary man. It takes the form of sticky smelly mixtures to prevent egg-laying, the removal of bots from the skin by pressure or the destruction of bots by application of grease or ointment. The species discussed above are the most common in India, as elsewhere.

Much has yet to be learnt of them and of the bots which probably attack wild animals in India. Cases are on record of bots in human beings but no precise details are available.

Biting Flies.

At least one species of fly, allied to the notorious tse-tse fly of Africa, is found in India biting cattle, horses and man. This insect [1] is not universally distributed in India; it breeds in manure, decaying vegetation and filth in places where animals are kept. The life-history occupies three weeks,[2] and the flies are found sitting on trees and plants near their breeding places.

They suck blood from cattle, horses and man, biting particularly in the early morning: the bite is said to be painful. This fly is instrumental in the spread of "surra" in horses and other animals. It is kept in check by hymenopterous parasites which are found in the larvæ and pupæ.

Screw Worms.

Certain flies lay their eggs or larvæ in wounds on animals, the maggots living in the wound and setting up inflammation and blood poisoning. The Screw Worm of the United States and the West Indies is notorious as a destructive pest, even attacking man and causing death. Similar maggots have been found in wounded cattle in India, though it is not known to what species they belong. These flies are allied to the common flesh flies and house flies, their normal breeding place being decaying animal matter. The treatment consists in smearing wounds, sores, etc., with antiseptic mixtures such as carbolised oil; a clean aseptic wound is not infested. If larvæ are already in the wound, they should be removed, the wound washed and plugged with antiseptic dressing. Such maggots are by no means uncommon in human beings in India and are due solely to uncleanness and the neglect of wounds and sores. The actual species concerned has not been ascertained.

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[1] *Stomoxys calcitrans.*

[2] As worked out by P. G. Patel in Nongpoh.

CHAPTER XXI.

BENEFICIAL INSECTS.

IN classing our insect life according to its food, we pointed out that whilst a very great number of insects feed directly upon vegetable life, a further large number derive their food from other insects. The latter we may term *beneficial insects,* since they are the greatest natural check upon the increase of the destructive insects which attack growing crops. Beneficial insects play a very important part in the economy of nature. Such is the rate of increase of the majority of herbivorous insects that they would, if able to breed continuously, overrun the earth and devour all vegetable matter. To this enormous increase is opposed a variety of conditions and forces, which result in regulating the increase of all classes of life. Climatic changes periodically put a check to the increase of animal life; the absence of food is a check, which is however largely inoperative under the conditions of modern agriculture; when these checks fail, the action of the beneficial insects becomes apparent, and we see one class of insects living at the expense of another and proving itself directly beneficial to man. These insects can be regarded as forming three large divisions: the *parasites* are those which live as larvæ within the bodies of their hosts; the *stinging predators* are those which store insects for the

FIG. 321.
An Ichneumon parasitic on large caterpillars.
(*Natural size.*)

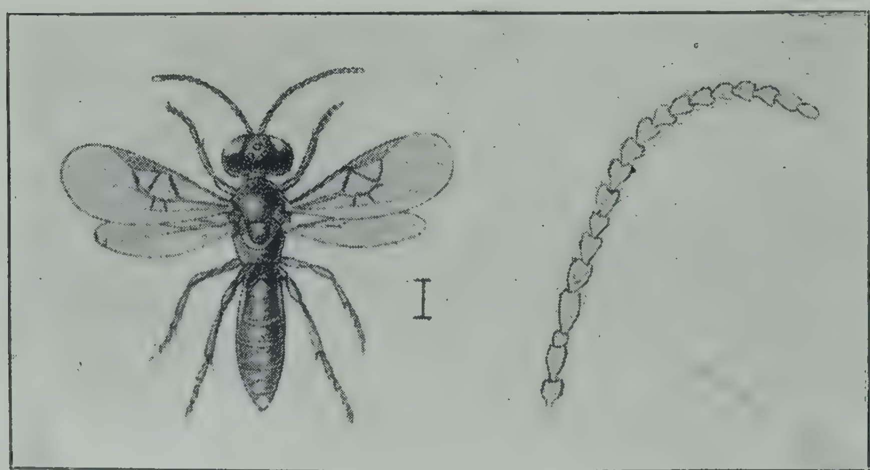

FIG. 322.
The parasite of the Moth-borer Caterpillar of Cane.
(*Magnified.*)

nourishment of their young, and the *predators* in general feed themselves upon living insects.

Parasites are found in the majority of species of insects which have been reared in India in captivity. The 'ichneumons' are *Hymenoptera*, not unlike wasps in appearance, which lay their eggs on or in the bodies of caterpillars, the larva which hatches nourishing itself at the expense of its host (fig. 321). The caterpillar continues to live and feed, moulting as usual; the parasite meanwhile grows larger and finally causes the death of its host. In many cases the larva comes out of the body, and turns to the pupa outside. In other cases it remains within the dead body until it emerges as a winged insect. Caterpillars containing parasites frequently die before they can become chrysalides; in some cases they become chrysalides and then die. A caterpillar may contain one or many parasites; as many as seventy small ichneumons have been reared from the body of a Cotton Stem-borer. Ichneumons can be captured in the field or more readily obtained by rearing various caterpillars and grubs, which will yield ichneumons in many cases instead of the perfect insect. Ichneumons

FIG. 323.
Parasite of the Egyptian Syrphus.
(Magnified five times.)

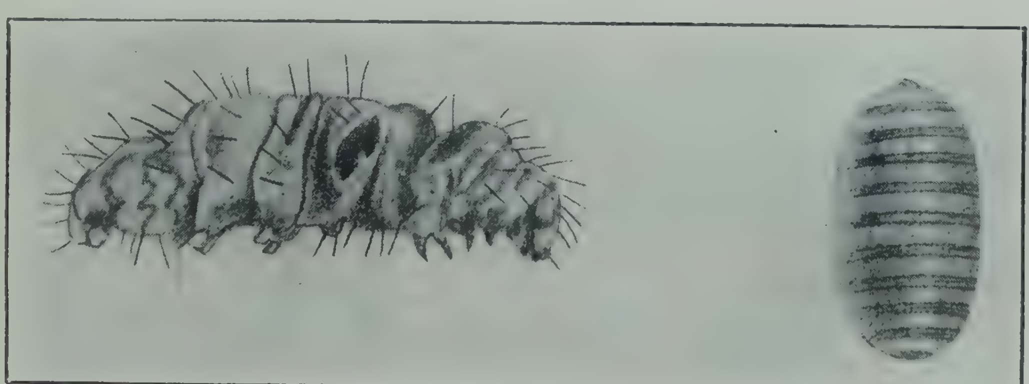

FIG. 324.
Dead Caterpillar showing hole of emergence of parasitic fly grub and the pupa of the grub. (Magnified three times.)

not only destroy caterpillars but the grubs of beetles, the maggots of flies, and the grubs of bees and wasps. In some cases, one ichneumon lays its eggs within the body of the grub of another ichneumon which is

already living in the body of a caterpillar; we then have one ichneumon parasitic upon another, a singular phenomenon, which checks the too great increase of the beneficial insects (fig. 323). Ichneumons also lay their eggs in such small insects as aphides, and even in the eggs of insects. One species lays its eggs in the eggs of the moth-borer of sugarcane and the eggs of many insects are thus destroyed.

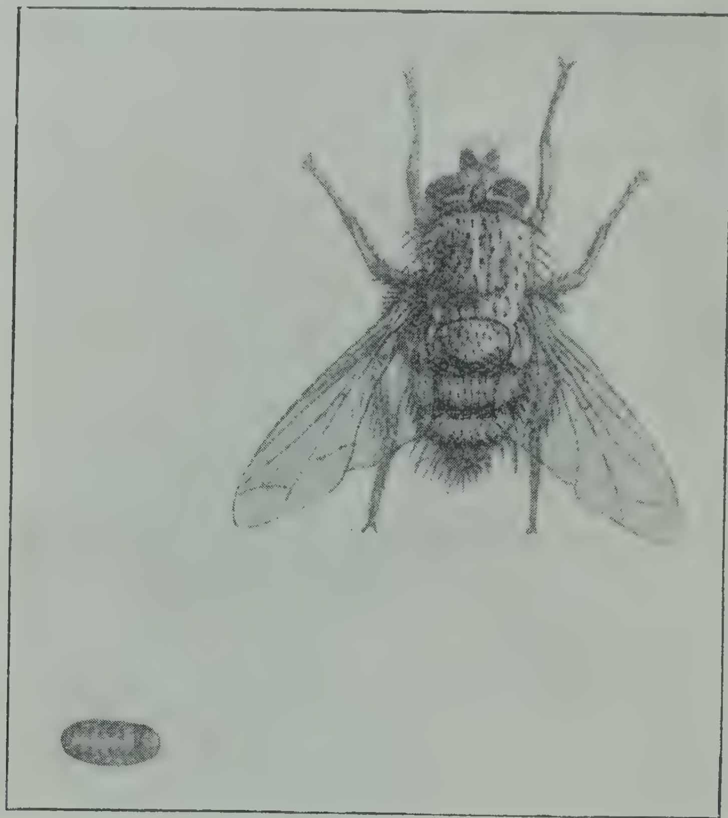

FIG. 325.
Fly whose maggot is a parasite on leaf-eating caterpillars. (Magnified.) Pupa below, natural size.

Besides the ichneumons, there are the parasitic flies, a large group of *Diptera* which behave very similarly to the ichneumons. These flies (fig. 325) resemble house-flies and are common in the fields. They lay their eggs on caterpillars, and other insects, the maggot that hatches destroying the caterpillar. As in other flies, the full grown maggot forms a brown seed-like pupa (fig. 324) usually coming out of the caterpillar before it does so. A species of parasitic fly lays its eggs on the Bombay Locust and another on the Red Cotton Bug.

FIG. 326.
The parasite of the maggot of the Rice Stem Fly. (Magnified.)

As a rule every species of parasite is found only on one or a few insects. The parasite of the Cotton Stem-borer is not the same as that of the Moth-borer of sugarcane. Parasites that we rear from distinct insects are usually distinct themselves, though the same parasite may be found in two species of insects which are very much alike. Every abundant caterpillar and very many beetle

grubs, fly maggots, etc., have their parasites; but parasites themselves are dependent upon these insects for food and become exterminated if their host is exterminated.

It is advisable not to destroy parasitic insects and when possible their increase should be encouraged. This is unfortunately rarely possible, but it is so when insects are collected by hand in large numbers as in handpicking Tur Leaf Caterpillars, or Cotton Leaf-rollers. In such cases, the collected larvæ and pupæ should be placed in any closed receptacle, as for instance, a box or an earthen pot covered with cloth. Whatever parasites there are hatch out and when the box or pot is carefully opened in the light, they fly away. As a rule the moths or butterflies that also hatch fly only in the dark or are too large to escape through as small an opening as the parasites can. Whenever possible it is advisable to put such collected insects into a box covered by a piece of glass; as the parasites collect on the glass, the moths hide away. If the glass is gently lifted the parasites escape to continue their useful work.

This applies also to eggs of insects, which, when collected, should not be burnt but placed in a vessel surrounded by water; the insects that hatch from the eggs cannot escape, but the parasites can fly away.

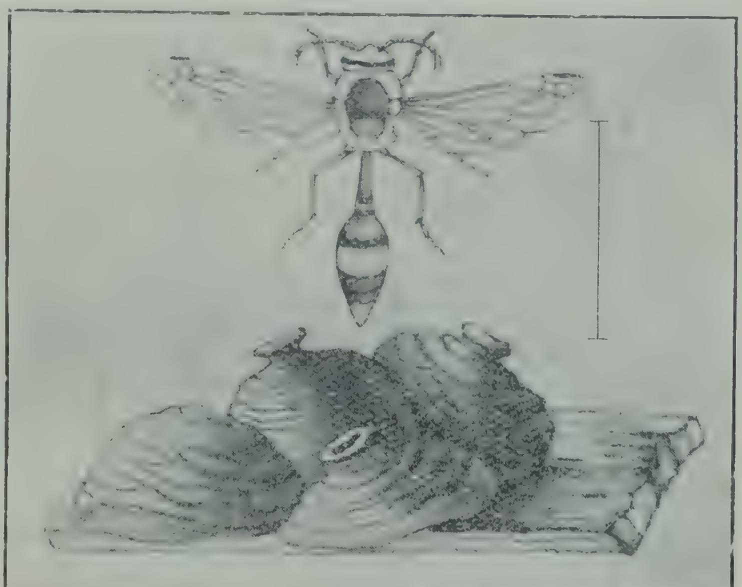

Fig. 327.
Wasp that stings caterpillars and lays them up in mud nests for its young.

The stinging predators are a small group of *Hymenoptera,* which have instincts of so high an order as to excite the admiration of all who study them. We may describe the life of one,[1] a common insect in the plains. This insect may be found in the fields flying among the plants evidently seeking for something. If watched with patience, it will be seen to seek for caterpillars, those green caterpillars so common on gram, tobacco, and other crops. Having found a large green caterpillar, it flies to it, seizes it, and stings it on the lower side; the caterpillar struggles, but the wasp holds fast and repeatedly stings along the lower surface between the legs. The caterpillar then becomes motionless and is helpless; the wasp seizes it, and flies off to a little distance where it has prepared a hole in the ground;

[1] *Ammophila lævigata.* Sm.

the hole is a narrow tunnel extending perhaps one inch into the soil; into this hole the caterpillar is dragged, and laid at the bottom; the wasp lays one egg upon it and comes out; it then fills up the hole with small lumps of earth, smooths it off carefully and goes away to repeat the process. If the caterpillar is dug up and kept under suitable conditions, it is possible to see what occurs. The egg hatches after a few days and the small white grub fastens on the caterpillar, piercing the skin and pushing in its head. It feeds upon the caterpillar, which lies still and motionless, and as it grows larger it stretches into the body of the caterpillar, slowly devouring it. In time the caterpillar is eaten out, only the skin remaining, and the grub has grown into a large white insect. It then spins a cocoon of tough silk, within which it turns to the pupa and eventually emerges as a wasp. It mates and, if a female, does as its parent did, preying upon green caterpillars (fig. 328).

FIG. 328.
Digger Wasp that stings caterpillars.

The habits of this insect are similar to those of all the stinging predators. The singular fact is that the caterpillar is stung in such a way as not to kill it but to paralyse it. If the caterpillar were dead, it would decay and the grub hatching would find no food; if the caterpillar were alive and could walk, it would walk away with the egg, which would be killed by exposure to sun and air. By paralysing the caterpillar the mother ensures a supply of living food for her young. Stinging predators are common in the fields; some make nests, others bury their prey in the ground, some are to be found in our houses (fig. 327). They prey upon all manner of small insects, upon spiders, and upon some of the larger insects. Their habits are extremely diverse and display an ingenuity that has excited the admiration

FIG. 329.
Lady-bird Beetle and its grub. (Magnified and natural size.)

of all naturalists. They are distinctly beneficial and aid in the checking of insects throughout the year.

Lastly we have the "predators," a vast number of insects which live by capturing and devouring other insects. These are really of two kinds, those which we find specially attacking particular classes of insects, and those which catch and devour all that they are able to.

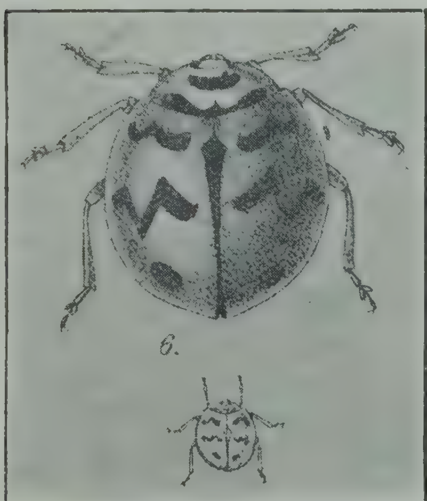

FIG. 330.
Six-spotted Lady-bird Beetle.

Of the first, there are many which are found attacking plant-lice, mealy bugs and scale insects and those should be familiar to every one.

The Lady-bird Beetles are small rounded beetles, about the shape of a split pea, coloured in red, yellow and black as a rule. The life-history in all is the same, and we may describe that of the commonest beetle in India, the Six-spotted Lady-bird Beetle.[1]

The female beetle deposits her eggs on plants where there are colonies of green-fly (*aphis*) or other food for the young. The eggs are yellow, almost cigar-shaped, about one-twentieth of an inch long, laid in little clusters of 10 to 20 eggs. In four or five days the eggs hatch, a tiny dark-coloured grub coming out. The grub has three pairs of legs, a body set with spines and tapering to the hind end, and is nearly black. It runs about, feeding upon other aphides and it is very voracious; it rapidly grows larger. Yellow and white spots appear on it after some days and it is then more easily recognised. The grub does not grow to a length of more than about one-quarter of an inch, living for about ten days. It then fixes itself head down by the tail, and the skin is shed, exposing the pupa. The pupa is round, hanging from the plant, of a dark-red or orange colour with black spots. Great numbers of these may be found on the plants when aphides are abundant, and they are very easily seen on the leaves.

FIG. 331.
Seven-spotted Lady-bird Beetle.

[1] 64. *Chilomenes sexmaculata* F. (Coccinellidæ.)

After about six days the beetle comes out, and it too feeds upon aphis.

Fig. 332.
Eggs of Green Chrysopa. (Magnified.)

The beetle is shaped like a half pea, the wings covering most of the body. There are six little black spots on the upper surface, the general colour being yellow or orange. The beetle has good biting mouth-parts and feeds actively upon aphis. The females lay about 90 eggs each, in little clusters, and then die.

Fig. 333.
Brown Chrysopa larva. (Magnified.)

The life of this beetle may be long or short, depending upon whether it can find food for itself and its young, when it will lay eggs. Large numbers of beetles are found during the cold weather and dry weather before the rains, seeking for aphides on which to feed. These beetles probably live a long time. When food is plentiful, the whole life from egg to perfect insects does not exceed four weeks, and one brood succeeds another rapidly.

As each beetle lays nearly one hundred eggs, and each grub that comes out eats from one to two hundred aphis per day, the destruction of aphis may be very rapid. This beetle is very abundant over a large part of the plains in India feeding principally upon cotton aphis. With it is another,[1] the Seven-spotted Beetle, which feeds upon wheat aphis in particular and becomes enormously abundant in aphis-infested wheat.

FIG. 334.
Cocoon of Green Chrysopa.
(Magnified.)

Other species include the very small brown beetles,[2] whose larvæ are clothed in dense white processes which give them the appearance of a mealy bug. These larvæ are found feeding upon cotton aphis, on tur aphis, on the cotton mealy bug and on many other common insects. There is a large number of other species common in the plains, but the above are the most important.

FIG. 335.
Brown Chrysopa Pupa. (*Magnified.*)

FIG. 336.
Green Chrysopa.

The lace-wing flies are very delicate green or brown insects, with large wings and golden eyes, which are found commonly upon plants attacked with aphis. They lay eggs which have the appearance of a rice grain set upon a small stalk. A number of these are laid together in a cluster on the leaf of the infested plant.

[1] *Coccinella septempunctata* L.
[2] *Scymnus* spp.

The larva that hatches is an active spiny insect, with long

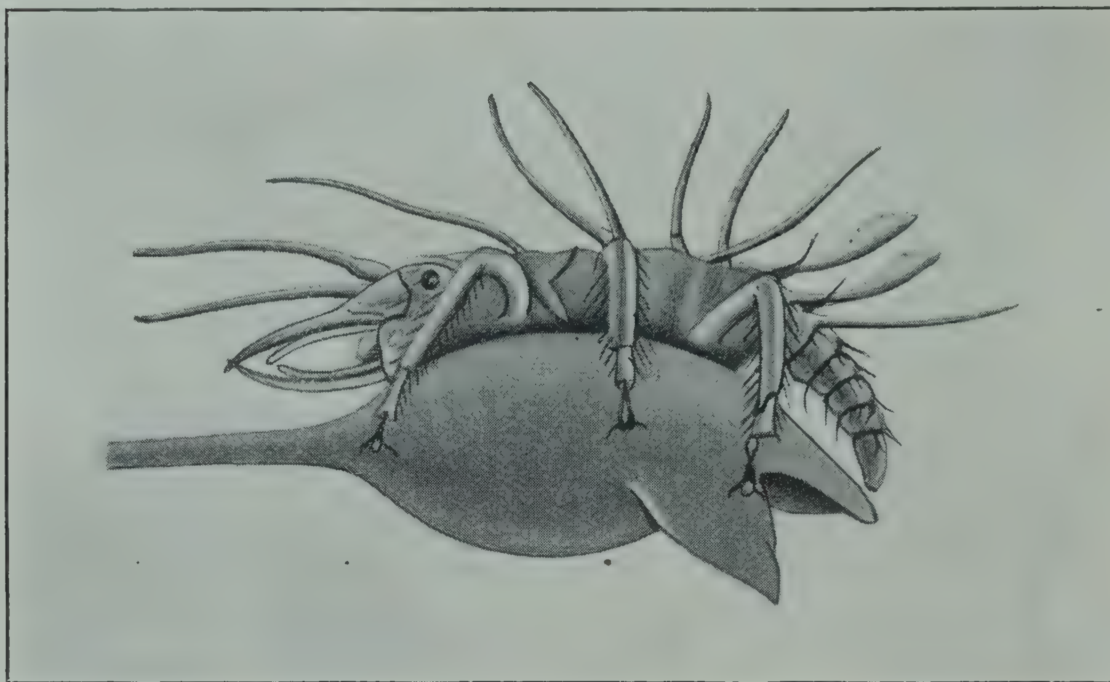

FIG. 337.
Larva of Chrysopa, just hatched, on the egg. (Magnified.)

sharp jaws; it runs about the plant seeking for aphis and when it finds one, the jaws are inserted and the juice sucked out till only the shell is left. In some species the larva covers itself in the cast skins of its victims and goes about with a thick mass of them on its back. This larva destroys a large number of the aphis before it pupates; the pupa is found in a small white cocoon or in a fold of the leaf under a thin covering. These insects are very numerous in the plains, though they commonly escape notice. A bad attack of aphis brings them in numbers and the flies are attracted to light.

FIG. 338.
Egg of Syrphus Fly laid on leaf. (Natural size and much magnified.)

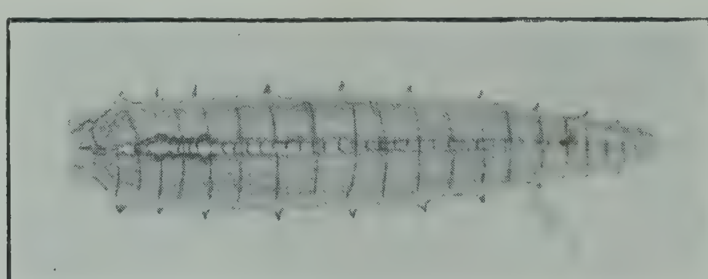

FIG. 339.
Grub of Syrphus Fly. (Magnified five times.)

The Syrphus flies are another important check on the plant-lice and may be found in any field where a crop is infested. The fly is a graceful

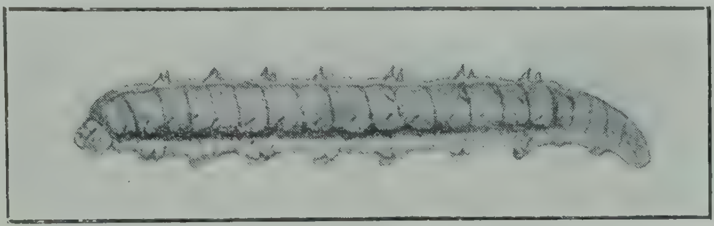

FIG. 340.
Grub of Syrphus Fly. (Magnified five times.)

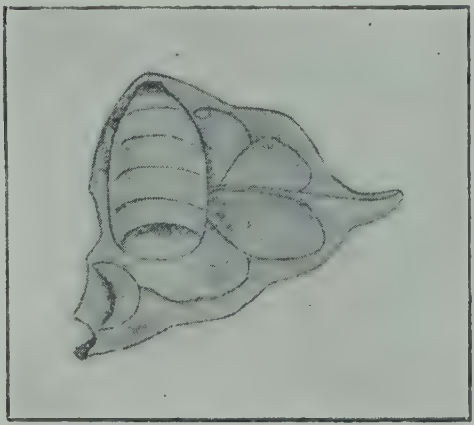

FIG. 341.
Empty pupa case of Syrphus. (Magnified five times.)

FIG. 342.
Syrphus Fly. (Magnified five times.)

two-winged fly, coloured in black and yellow, which "hovers" in a very noticeable manner, remaining motionless on the wing suspended in

the air; large numbers can be seen in a wheat-field where aphis is abundant. These flies deposit small white eggs singly on the wheat near the colonies of aphis; a maggot hatches, formed like the typical fly maggots, thick at the hind end, tapering to a point at the headless front end, with a pair of strong hooks in the mouth; the maggot is green and moves slowly about the leaf, feeling in every direction. It is blind and strikes about it in a curious tentative fashion, feeling for a victim. The plant-lice caught by it are drawn in with the hooks, sucked out dry and thrown aside. These maggots demolish whole colonies of the plant-lice and finally turn to the pupa on the leaf. At least one species[1] is very common in the plains, feeding on aphis of all kinds.

Fig. 343.
Ground Beetle that attacks the young North-West Locust.

Many insects are found feeding upon special destructive insects. The Six-spotted Tiger Beetle[2] is abundant in rice-fields in Bengal; it flies with great rapidity and feeds upon the Rice Bug. A ground beetle[3] is said to feed upon the young North-West locusts. The larvæ of other ground beetles feed upon such caterpillars as live exposed on the plant; these are small slender black insects, which congregate on plants infested with small caterpillars and destroy them.

Fig. 344.
The Six-spotted Ground Beetle.

There are in addition many insects which prey promiscuously, their life history not being specially modified in relation to their prey as in predators discussed above.

[1] *Syrphus ægyptius.* Wied. (Syrphidæ.) | [2] *Cicindela sexpunctata* L. (Cicindelidæ.)
[3] *Calosoma orientale* Ho. (Carabidæ.)

The dragon flies (fig. J, page 293) which hawk in the sunlight are catching small flying insects and must account for a vast number of the smaller forms of insect life daily. The praying mantises are common in jungle and bushy vegetation, where they wait for butterflies and other large insects. The ant-lion in its pit destroys the smaller creatures that walk on the soil. Wasps when hungry catch caterpillars and eat them; the *Mantispa* and the *Panorpids* lurk in the deep woods and jungles, hunting down the weaker flying insects for their food. Everywhere on the soil are the ground beetles, the flat dark beetles which live wholly by their prey and which gather so abundantly where insects abound. Even underground the mole cricket and the *bherwa* drive their tunnels, seeking out the grubs and other insects hiding there. In the bark of trees are many beetles, wholly carnivorous and devouring the many forms of insect life that dwell there. Even the plant-feeding caterpillar is in some cases predaceous, the caterpillar of one butterfly[1] and several moths[2] feeding upon mealy bugs. Among the flies the big hairy robber-flies are predaceous and catch grasshoppers, bees, wasps, and other strong insects. Many other *Diptera* are predators, as are a large part of the bugs, distinguishable by their curved beaks. The total list would be a very long one and embrace parts of the large orders and of very many families.

FIG. 345.
A Praying Mantis.

Predaceous insects are common everywhere and in every possible situation where other insects get food. They cannot always be identified as predators until their habits are accurately studied, and one cannot at sight recognise a predaceous from a herbivorous insect in every case.

To the observer of nature, these insects are of interest, and the deeper one looks the more one feels the wonder of that balance of life which is apparently so evenly maintained. It is very rarely that an insect becomes abundant and for the time outwits its foes; the more it does so, the more do its foes prosper till they reduce it to its level; nor do

[1] *Spalgis epius* F. (Lycænidæ.) | [2] *Eublemma* p., (Noctuidæ.), & Various Tineidæ.

the foes escape but they in turn are checked till all species can live and fill their place in the natural world, the balance of life evenly kept between the herbivores, the scavengers, the parasites and predators. In this connection we may mention the birds, which do so much to keep the

Fig. 346.
A Praying Mantis.

balance even by snapping up all insects that become abundant; an insect that escapes its foes and outruns its parasites is apt to fall a victim to birds as do the termites when they emerge in swarms; if not to a bird, then to a lizard, a toad or a bat. All these are useful and all should be encouraged. A large number of birds are wholly insectivorous, a large number are partly so and every one of these deserves protection and encouragement. They fill an extraordinary place in nature as they move from place to place, they are nearly omnivorous insect-eaters and they snatch up the floating balance of insect life, acting as a kind of safety-valve. For the birds we should plant trees, which rarely harbour crop pests, and especially such trees as figs on which the mynas gather and feed.

APPENDICES.

APPENDIX A.

USEFUL INFORMATION.

COST OF INSECTICIDES.

THE cost of insecticides depends on the local prices of the various ingredients, but the following may be taken as average prices per 100 gallons (12 maunds) :—

	Rs.	A.	P.
Lead arseniate	1	0	0
Kerosene emulsion, soft soap	3	0	0
„ „ hard „	3	0	0
Rosin wash	3	0	0
„ compound	2	0	0
McDougal's Insecticide	3	4	0
Crude oil emulsion	1	12	0

The quantity of insecticide used per acre on various crops is as follows :—

Cotton or Tur	80 to 100 gallons.
Young Sorghum	60 „
Sweet Potato, Groundnut, etc.	60 „
Coffee	80—160 „
Tea	75—150 „
Mustard	60—100 „
Wheat	50—80 „

FORMULÆ.

1.—Lead Arseniate.

Paste.—One pound in 66 gallons of water with the addition of 3 pounds of lime and 6 pounds of jaggery or gur if available. Stir well before applying. One ounce of paste is the charge for a kerosene tin full of water or for the Knapsack Spraying machine.

Powder.—One pound in 100 gallons of water with 5 pounds of lime and 10 pounds of jaggery or gur. Stir well. The charge for a kerosene tin of water is two-thirds of an ounce, about a teaspoonful.

One pound mixed well with 20 to 50 pounds of any fine neutral powder, such as lime, ashes, road dust, etc.

2.—Kerosene Emulsion.

Boil half a pound of sliced bar soap in 1 gallon of water till dissolved. Take off the fire and add 2 gallons of kerosene, agitating or beating the mixture till the kerosene is completely emulsified. This is stock solution to be diluted with 6 to 10 parts of water before use. With hard water more soap is required.

3.—Crude Oil Emulsion.

One gallon of emulsion mixed with 66 gallons of cold water. The charge for a kerosene tin full of water is half a pint.

4.—McDougal's Insecticide.

One gallon of emulsion mixed with a few gallons of water and then made up to 60 to 100 gallons

5.—Rosin Compound.

Powder 2 pounds of rosin and 1 pound of washing soda (sodium carbonate) crystals. Place these in a kerosene tin or large metal vessel, with enough water to cover them, and boil.

Continue boiling till both are dissolved and then slowly add cold water to the steadily boiling fluid. Water is to be added, a very little at a time, for fear of chilling the liquid, and the mass should gradually be brought up to 2 gallons. The liquid changes as the boiling proceeds, becoming thick and soapy; after boiling for half an hour or longer, the liquid becomes clear, thin, of a deep brown colour. Continue boiling, pouring a few drops of the mixture into cold water at intervals; at first the wash on mixing with cold water forms a slightly milky opaque fluid, but after some minutes, further boiling, it forms a clear amber liquid on being mixed with cold water.

This is the test of the liquid being finished and it should on cooling remain clear. To this stock solution 6 gallons of water may be added to make the strong wash, 10 gallons to make the normal wash. One pound of rosin is used for every 4 to 6 gallons of wash required, and half as much soda. The wash keeps indefinitely if properly prepared, and it is best to keep the stock solution and dilute it as required.

6.—Rosin Wash.

Powder 3 pounds of rosin and add it to half a pound of caustic soda (98 per cent.) dissolved in half a gallon of water in a kerosene tin. Boil and when the rosin is dissolved add half a pint of fish oil. Continue boiling, slowly adding cold water, till the mixture amounts to 3 gallons. If the mixture is then a clear thin brown liquid, which mixes with water producing no milkiness, it is finished and may be removed from the fire. Dilute with 12 gallons of water to make wash ready for use. One pound of rosin is used for every 5 gallons of wash required. If caustic soda of 98 per cent. purity cannot be used, use a proportionate quantity of 70 per cent. ($\frac{3}{4}$ lb.) or lower grade caustic.

7.—Tobacco.

Soak 2 lbs. of tobacco in 2 gallons of water for 24 hours or boil for half an hour. Dissolve $\frac{1}{2}$ lb. bar soap or 1 pint of soft soap in the mixture. This is the stock solution. Dilute with seven parts of cold water.

8.—Sulphur.

Mix 20 lbs. of ground sulphur or flowers of sulphur with 80 pounds of sifted or slaked lime or wood ashes.

An alternative is to boil 5 pounds of sulphur and 5 pounds of lime in water and make up to 40 gallons with water.

Another formula is to mix 8 pounds of sulphur with 10 pounds of soft soap in boiling water and make this up to 40 gallons with cold water.

9.—Kerosene Milk Emulsion.

Mix and churn or shake well :—

1 gallon Sour milk . . . . . 2 gallons Kerosene	Stock solution.

Dilute with 8 to 15 parts of water.

10.—Borer Wash.

1 pint Crude carbolic or phenyle . . . 2 lbs. Soft soap (or hard soap, ⅓ lb.) . . 1 gallon Water, hot	Dissolve soap in hot water, stir in carbolic. Add ten gallons of water and enough clay to thicken it.

11.—Carbon Bisulphide.

1 oz. per 100 lbs. of grain.

1 to 1½ lbs. per ton of grain.

1 drachm (teaspoonful) per cubic foot of space.

1 oz. per 15 cubic feet of space.

12.—Cockroach Paste.

1 oz. Boracic acid . . . . . . 2 oz. Jaggery, or syrup	Mix well.

13.—Gondal Fluid.

4 oz. Dekamali gum (Gum of *Gardenia gummifera*).

8 oz. Hing (Asafœtida).

8 oz. Gugul (Bazar aloes).

3 oz. Handiba bagda (Castor cake).

Mix well with water, add clay to thicken and paint on. It ferments and must be kept open. Total cost 14 annas.

14.—Soluble Arsenic.

1 part White arsenic . . . . . 4 parts Washing soda	Boil in water till dissolved.

For watering foundations, earthwork, etc., dilute with 30 parts of water. (Is an excellent weed-killer.)

15.—Lead Arseniate.

4 oz. Arseniate of soda . . . . . 10 oz. Acetate of lead	Dissolve separately in water and mix.

16.—Arseniate of Lime.

1 lb. Arsenic . . . . . . 4 lbs. Washing soda . . . . . 2 gallons Water	Boil till dissolved. Make up to 4 gallons with water.

Add one pint to four gallons (kerosene tin full) of water and add 4 oz. lime.

This is a substitute for lead arseniate.

17.—Arseniate of Copper.

$2\frac{1}{2}$ lbs. Copper sulphate . . . . . . 4 gallons Water	Dissolve. Stock solution A.
1 lb. White arsenic . . . . . 5 lbs. Washing soda . . . . . 2 gallons Water	Boil till dissolved: make up to 4 gallons. Stock solution B.

Mix equal parts of A and B, and dilute with 35 parts of water.

This is equivalent to lead arseniate standard solution.

18.—Kerosene and Lime.

20 parts Lime . . .	(by volume)	Fine road dust or any fine neutral powder will do.
1 part Kerosene . . .	(by volume)	

The same mixture can be made with sanitary fluid, cheap phenyle, or other carbolic fluids.

STRENGTHS OF INSECTICIDES.

The following table gives the weights or volumes of insecticides to be used, calculated for the kerosene tin or spraying machine holding four gallons:—

—	Weak.	Standard.	Strong.
Lead arseniate, powder	3 $\frac{1}{3}$ oz.	$\frac{1}{2}$ oz.	1 oz.
Ditto, paste	7 $\frac{1}{2}$ oz.	$\frac{2}{3}$ oz.	$1\frac{1}{2}$ oz.
Rosin wash, stock solution	2 pints	3 pints	5 pints.
Rosin compound, stock solution . . .	3 quarts	1 gal.	$1\frac{1}{2}$ gal.
Kerosene emulsion, stock solution . . .	2 pints	3 pints	5 pints.
Crude oil emulsion	3 $\frac{1}{3}$ pint	$\frac{1}{2}$ pint	1 pint.
McDougal's insecticide and fungicide . .	3 $\frac{1}{3}$ „	$\frac{1}{2}$ „	1 „
Tobacco decoction	2 $\frac{1}{2}$ „	1 „	2 pints.
Kerosene milk, S. solution	2 pints	3 pints	5 „

Arsenic.—The fatal dose for an adult is from one to two grains, equivalent to three to five grains of lead arseniate, obtainable by drinking from half to a third of a

pint of standard wash. The antidote is an emetic followed by oil and lime water, soap suds or milk; an emetic is made by mixing mustard flour one tablespoonful, common salt one teaspoonful, and water ten to twelve ounces.

WEIGHTS AND MEASURES.

16 dram .	make	1 ounce (oz.)	=	$2\frac{1}{2}$ tolas.
16 ounces .	„	1 pound (lb.)	=	8 chittacks.
28 pounds .	„	1 quarter (qr.)	=	14 seers.
4 quarters (112 lbs.)	„	1 hundredweight (cwt.)	=	1 maund 14 seers.
20 hundredweight	„	1 ton	=	$27\frac{1}{2}$ maunds.
4 gills .	„	1 pint (pt.)	=	10 chittacks.
2 pints .	„	1 quart (qr.)	=	1 seer 4 chittacks.
4 quarts .	„	1 gallon (gal.)	=	5 seers.

1 fluid ounce weighs 1 oz.

1 pint (20 fl. ounces) of water weighs $1\frac{1}{5}$ lbs.

1 „ („ „) of kerosene weighs $13\frac{1}{2}$ oz.

1 lb. of kerosene measures $1\frac{1}{5}$ pint.

1 pint of slaked lime weighs 13—14 oz.

1 pint of lead arseniate powder weighs 28 oz.

1 gramme	=	15·432 grains.
1 kilogramme	=	35 oz. 120 grains.
1 ounce	=	28·35 gramme.
1 pound	=	453·58 „
1 litre	=	$35\frac{1}{5}$ fl. oz.

TREATING COTTON SEED.

For five seers of seed, mix two handfuls of clay, one of cowdung and enough water to make a paste. Rub the seeds in this mixture, letting them fall through the fingers as they get covered. Dry in the shade. To test them, throw the seeds into water, when all that float may be removed as bad.

SURFACE CATERPILLAR BAIT.

For five acres, mix one maund (40 seers) of bhusa with six gallons (30 seers) of water in which one seer of white arsenic (*Sambul*) and two seers of gur or jaggery have been dissolved. This makes a paste which is put down over the field in small heaps about two yards apart.

To make a bag and frame with opening of four feet by two feet.

Sufficient strips of cloth are taken, each fourteen feet long, sewn together by their long edges to make a piece fourteen feet by six feet. The two ends are then brought together and the sides sewn up. This makes a flat bag, to which strong cloth tags are sewn, the first at one seam, the next two feet from that, the third four feet from the second, the fourth two feet from the third and four feet from the first. Bamboos of two feet length are fixed between the two pairs of tags two feet apart and the bag is ready (*see* Fig. A).

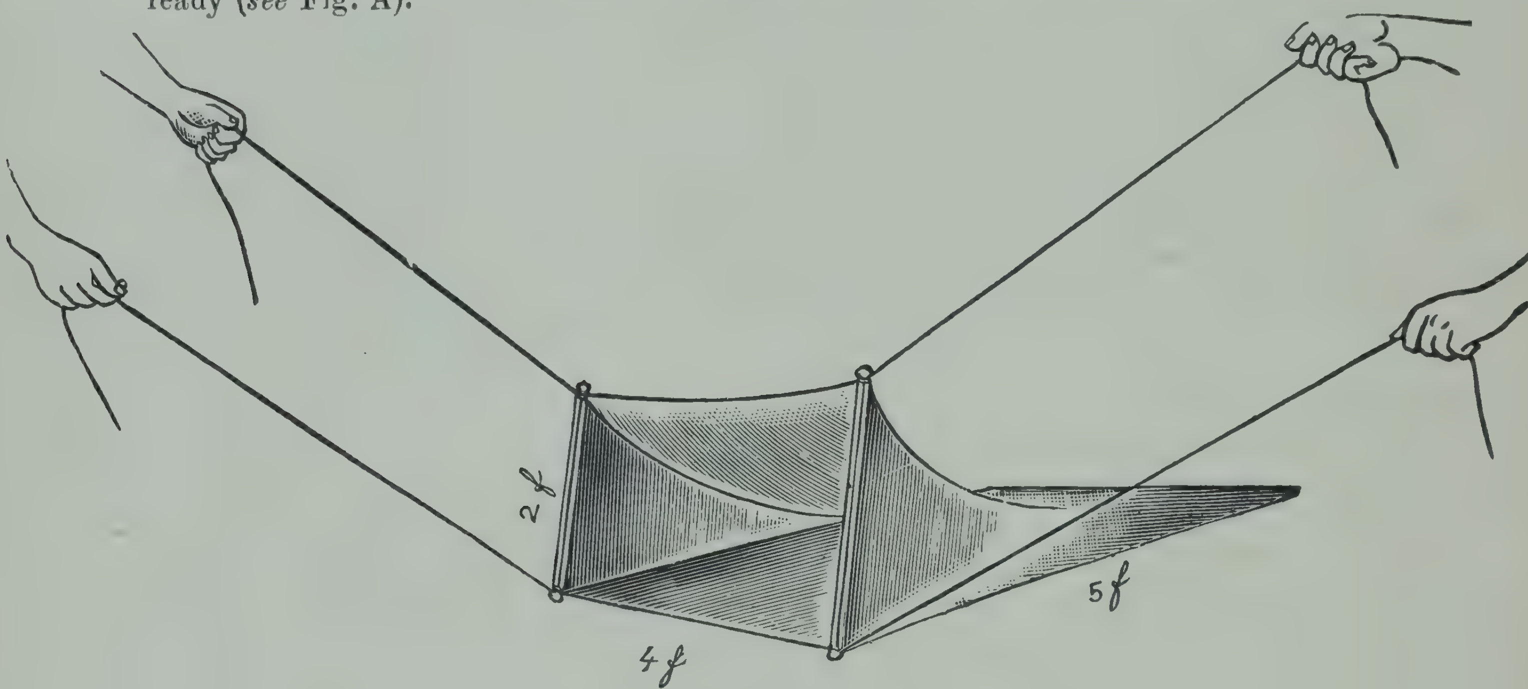

FIG. A.
Bag with bamboos ready for use.

The frame is made of four pieces of bamboo, (*a*) each four feet three inches long laid in a square, the ends of two bamboos on the ends of the other two. Two cross-pieces (*b*) of split bamboos, each five feet eight inches long, are laid diagonally across

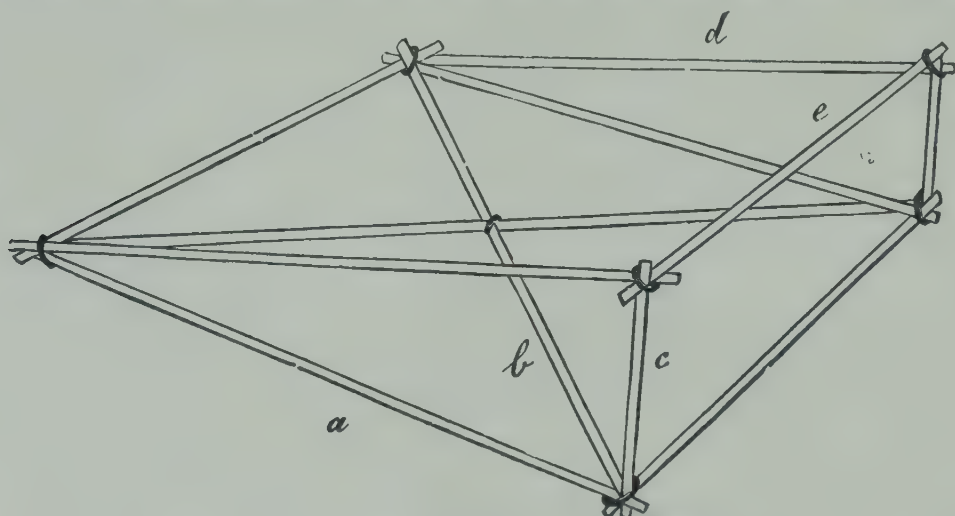

FIG. B.
Bamboo frame.

the square. Two pieces of bamboo, each two feet three inches long (*c*), are placed upright at the corners of one side, and two split bamboos (*d*), each four feet eight inches long are placed from the top of these uprights to the nearest corner. A cross bar (*e*) four feet three inches long is then placed to unite the top of the two uprights (*see* Fig. B).

As the bamboos are placed in position they are bound with string or fibre in the order given above. Enough bamboo should project at the ends to allow of their being bound together. This makes a frame to the front of which the bag above is attached by the tags.

In these figures three inches extra length is allowed to permit of the bamboo being bound; the resultant frame is then of the size to accommodate the bag. The two feet long bamboos used for keeping the bag opened are inserted only when the bag is used alone; when the bag is attached to the frame these bamboos are removed and the tags of cloth knotted to the frame, so that the bag can be at once removed and twisted up. In place of bamboo, strips of wood may be used.

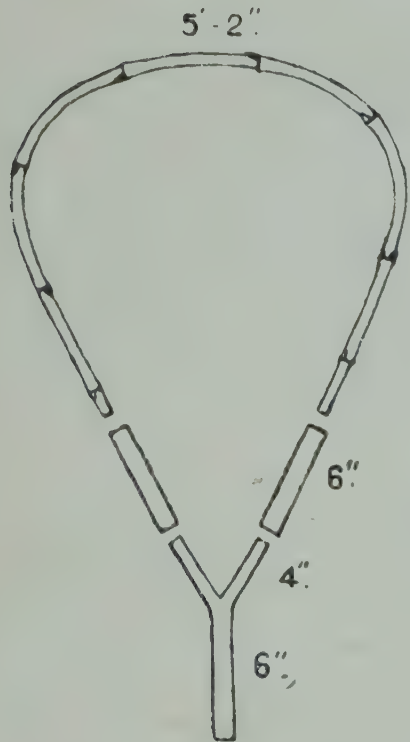

Fig. C.
Rough net frame in pieces.

The Hand Net.

Cut a Y piece (of guava, jamun or litchi wood) the stem six inches long and about three quarters of an inch in diameter, the arms four inches in length and half an inch in diameter: two hollow bamboos six inches long, the bore a little larger than the arms of the Y so that they fit tightly: a green bamboo slip, five feet two inches long, half an inch in diameter. These fit together as in the diagram and make the net frame.

For the net take two pieces of muslin, each two feet seven inches square; turn over one inch to make a hem, cut each piece along the thick black line of the diagram and sew the cut pieces together along this line, not along the double hem. Sew on to the hem a piece of cloth one inch wide to pass the bamboo through. The long bamboo is then passed through the cloth bag, and inserted at each end into the tubular bamboos which are fixed to the Y.

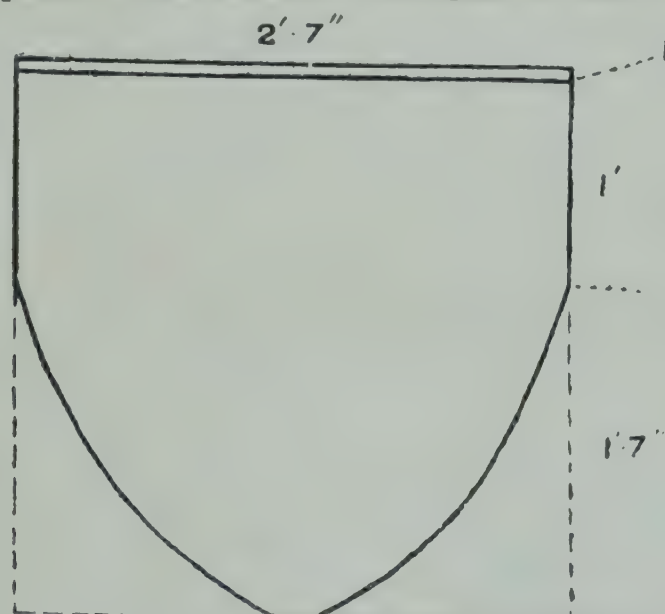

Fig. D.
Muslin piece for bag.
(Cut two pieces to shape shown and join along curved edges.)

APPENDIX B.

COLLECTING, PINNING, SETTING.

THERE is possibly no better field for the student of insects than India ; the variety of climate, of vegetation and of physical features means enormous number of species of insects, which flourish each under the conditions suited to them. At all times of the year insects are to be found at work and those who specially study one group, as also those who are interested in insect life as a whole, will always find abundance of material at hand.

FIG. E.
How to pin a Beetle.

It is unfortunate that, as elsewhere, the study of one sub-order, the Butterflies, has occupied so large a share of the work of the Naturalist in India. If the attention given to this group had been more equally distributed over the insect world, there would be a far wider knowledge of the insects as a whole. In spite of the volumes on butterflies, moths, plant bugs, bees and wasps, the insect world of India is very little known. The beetles are almost untouched ; the grasshoppers, crickets, mantids, stick insects and other *Orthoptera* have been little worked at ; and there is little on record in regard to flies and the smaller species of plant bugs and sucking insects. This refers only to their collection and classification. In the far wider field of biology how little is recorded ; with an almost unparalleled variety in the insect world, there is little known of the life histories, the habits, the beautiful adaptations of even the common insects. The writings of E. H. Aitken illustrate what a splendid field there is for simple observation and study of the manners and habits of the most familiar insects ; and in the present state of our knowledge, the wider problems of distribution, relation to climate, migration, etc., cannot be entered upon.

There is abundant work in every group, work not less interesting in biology or in the study of less popular groups than that which has been done for butterflies. The condition of the collections at the Indian Museum, the pages of the Asiatic Society and Bombay Natural History Society's Journals illustrate the very scanty nature of the recorded work on Indian insect life, and it is assuredly within the reach of every observer to add to this knowledge and carry on the work. It is needless to enlarge on the value of this work ; those who study Nature do not consider the value of what they do but find an added joy in life in their work ; they then find it imperative in the interests of all naturalists to put on record what they have done and help to build up the fuller history of the insect world.

FIG. F.
A pinned Bug.

In the entomologist's world at present, systematic work, that is classification and nomenclature, engrosses a far too large portion of the study devoted to the subject. Of the thousands who study and write about classification, there are but tens who

turn to the wider problems of biology or even to the simpler work of "life histories." In India, where entomological work is little carried on, I would plead the necessity of life history work, or if systematic work is essential, at least the study of groups less known than the butterflies. In the popular mind, entomology is "butterflies," whereas the butterflies are not one-twelfth of the known insect world and are probably not one-fiftieth of the actual species of insects now existing. Their beauty and large size impress them on our minds; but they are from some points of view the least attractive group, as they are almost without exception the least important in their influence on agriculture and man's welfare. To the systematist, the beetles and the flies offer unrivalled fields of work, both little touched as yet and in both of which very valuable work has yet to be done before the classification of these orders can be fully carried out. The mantids, crickets, cockroaches, grasshoppers, and other *Orthoptera* have been barely touched, from the biological as from the systematic side. *Myrmeleonides*, *Mantispides*, *Hemerobiids* and other *Neuroptera* are far commoner in India than in some parts of the world, and there is a splendid field here for life history work. The insect life of fresh water, of the streams, ponds, tanks and lakes has not been entered upon and would yield most valuable results. A very slight attention paid to scale insects has yielded much that is new, and the smaller species of plant bugs are found in very great variety everywhere. There is no lack of absorbing work and there should be no lack of workers in a country where so many have to find their own interests and hobbies, and live surrounded by the marvellously varied insect world. The naturalist in India has two great advantages not to be found everywhere. Publication is easy in the pages of the Asiatic Society or Bombay Natural History Society's Journal, which bring the work before an appreciative audience; the Indian Museum is there to help and is glad to receive specimens which are then part of what I may call the National Indian Collection, and really part of the National Collection gathered at the British Museum of Natural History in South Kensington. Through the Indian Museum, the help of the workers in the British Museum is readily obtained and the Indian Museum reference collections, though not complete, have been worked on by the leading European specialists.

FIG. G.
A pinned Moth, wings closed.

Collecting.

In the popular mind, an entomologist is a temporarily insane person, usually hot, flushed and panting, who careers wildly after butterflies armed with a large net. The real entomologist is probably to be found in the fields, with no net or other appliances except a few pill boxes, a knife and a good lens. Collecting differs according to the group to be collected; those who want to know the ways and habits of the common insects will spend hours out in the open simply watching. The best knowledge of the insect fauna of a district is got by patient watching. As soon as a particular species becomes quite familiar

FIG. H.
A pinned Moth, wings set.

one collects perhaps two of each sex for purposes of identification. As time goes by one gets to know the ways and habits of all the common insects and gradually acquires a real knowledge of the fauna of the district. This is the thorough and intimate knowledge which enables one to know why an insect is in a particular spot,

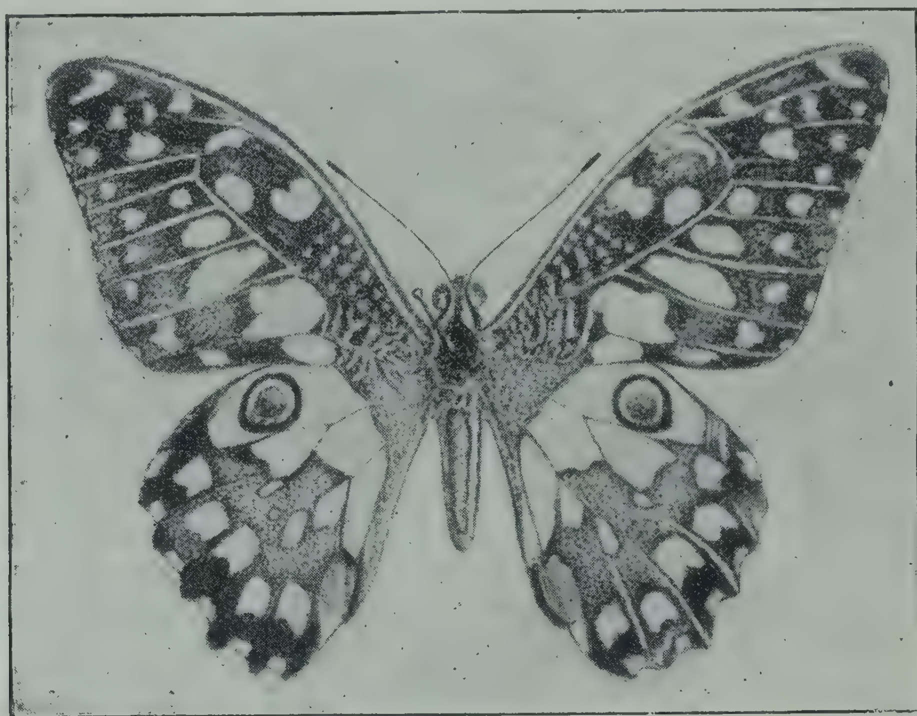

FIG. I.
The Lemon Butterfly. To show setting of wings, the hind margin of forewing at right angles to the body.

what it is doing and what its life is. This is, to the writer at least, the real work of the entomologist. It is then easy to collect all available specimens of any one group and the actual collection is subordinate to the field work, that is, is simply an index to the knowledge acquired of the local insect life. With that index, one can sit down and write the experiences for the benefit of the entomological world, and there would then be a speedy advance in our knowledge of the insects of the country. As an outcome of this, the study of a particular group can be taken up, and the work extended over a large area. This then becomes a valuable piece of work, valuable in proportion as it is based on thorough familiarity with the insects of one district and on the whole life of the insects in question, not simply their external structure or the venation of the wings. The tendency to commence straight away on the study of one group is deplorable ; it leads to purely systematic work, counting the spines on the margins of the tibiæ or the hairs on the pygidium, and there is no basis for comparative work and no understanding of the enormous value of biology. The study of dried insects is not entomology ; it is but a small part. Field work, involving more than mere collecting, is the backbone of entomology, and the last thing really wanted is the name of the insect, whereby to find out what others have said about it. Collecting, therefore, varies with the aims of the entomologist, and becomes an entirely different thing as he is intent on different aims. To the student of each group, different appliances are necessary ; to the beginner, to the naturalist pure and simple who wants to know the insects of his district, the sole requirements are boxes, a knife, a lens, and perhaps a net and killing bottle.

The boxes most useful are card boxes with a glass bottom (*not top*). They can be bought or are made by the North West Soap Company, Calcutta. At a pinch old match-boxes are very good. A strong knife is handy for digging and for extracting "borers." A lens is absolutely necessary, and is best got from London or Germany. I prefer Leitz's aplanatics, magnifying 10 or 16 diameters, but there are many patterns of aplanatic and Steinheil lenses that are equally good. The handiest net I know of is the so-called kite or balloon net (fig. R, page 302), made of four pieces of cane, a brass Y and a bag of green muslin. Killing bottles vary for different groups, but the cyanide or B. C. bottle is best for general work.

It is impossible to say anything in detail of special collecting in each group. *Aptera* are got by careful search in decaying vegetation, bark, under leaves, in all sorts of nooks and odd places. A camel-hair brush and a bottle of absolute alcohol or 95 % spirit is the best way to secure specimens unhurt, unless they be taken home alive with some damp material in a box. The absolute alcohol and brush secures perfect specimens of the active *Campodea* or *Collembola* forms, and they die rapidly in the alcohol.

Orthoptera vary with the family. Earwigs are found on the ground in woods or in flowers. Cockroaches under leaves or among low plants or on the bark of trees. Mantids, Phasmids, Grasshoppers, in crops, on plants, on bushes. Crickets among fallen leaves, in bushes, in the ground, etc. A net is useful for grasshoppers, but sharp eyes and hands are all that the other families require.

Neuroptera want a net ; dragon-flies are everywhere ; *Hemerobiids* are on crops chiefly or among bushes under trees ; *Myrmeleonides, Mantispides, Ascalaphides* under trees out in the sun. *Perlids, Sialids, Ephemerids* and Caddisflies near fresh water. Termites in their nests or at lights. *Embiids* come to lights. *Psocids* are on trees and bushes. *Mallophaga* on birds, etc. There is a big range for the Neuropterist and an almost unexplored one.

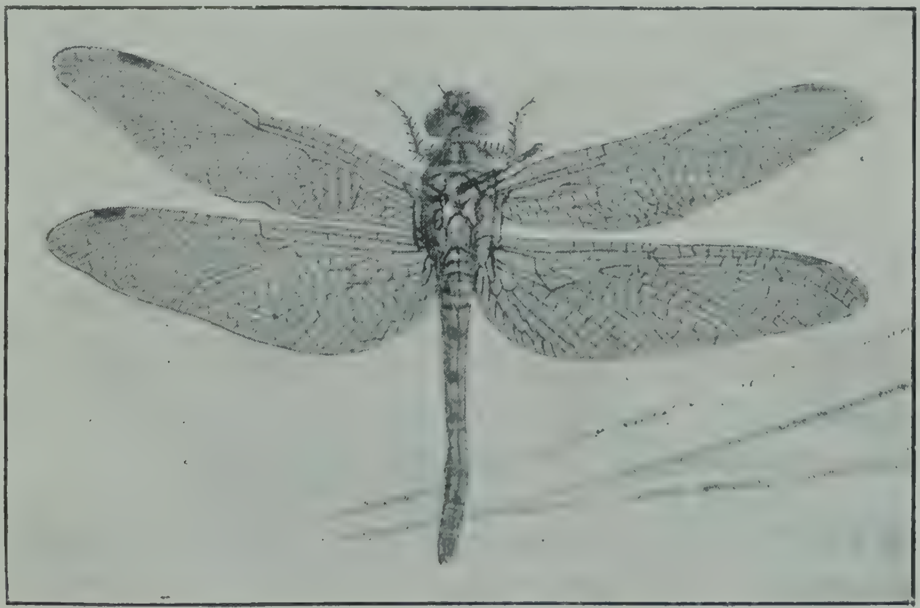

FIG. J.
A pinned Dragon-fly (Neuroptera).

Hymenoptera distinctly want a net in most cases, and far more necessary than collecting is the patient watching and breeding. Benzene is a peculiarly good

killing agent, a little vapour being sufficient. Chloroform should not be used as it turns yellow to red in many cases.

They are far too large a group to attempt any summary of and they can be caught from early morning to sunset, and in the evening are often easily captured asleep on plants.

Coleoptera again are far too large to deal with. Every family wants separate collecting. In this group no chance of rearing from the grub should be lost. So little is known and the difficulties are so great that one may look on a reared beetle as something of an achievement and hasten to put the facts on record. This of course does not refer to household plagues which rear themselves far too easily in cheroots, flour, etc.

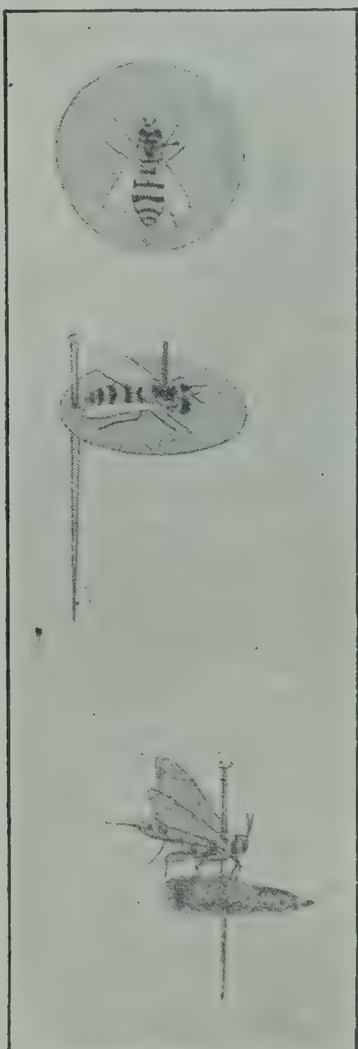

FIG. K.
Fly pinned on disc (above). Ichneumon and moth pupa case from which it emerged, on one pin.

Carcases may be mentioned as a good bait, however small they are, and droppings of any kind yield many varieties, as does the bark of old trees. Benzene or cyanide *are excellent* for killing, and no harm is done by immersion in benzene.

Lepidoptera have fortunately demanded breeding as a necessity of good specimens, hence we know the life histories and caterpillars in many cases. The adventitious aid of "sugaring," and of lights and light traps, enable the moth-hunter to secure many treasures. Chloroform or cyanide is best for killing, not benzene.

Diptera need a net, or better still, are easily reared when the grubs are got. Grubs live in all sorts of places and there is no more widely diffused or more interesting group than this. For variety of habits and habitat, the fly grubs are fully equal to the beetles and beetle grubs, and are more easily reared. The collector will find them everywhere, on the wing or as grubs. For killing I prefer a dry tube and a benzened cork. Have a dozen tubes of one size, corked, one containing benzene. Capture your fly, transfer to a clean dry tube, and then holding your thumb over the mouth of the tube transfer the cork of the benzene tube to the tube with the fly in and replace by the clean cork. The fumes of benzene from the cork will then speedily kill the fly. Flies must never be wetted with any liquid whatever.

Hemiptera can be killed in any fashion if they are big and hard. Soft ones may need to be preserved in formalin, as all *Aphidæ* (Green-fly), etc.

A net is hardly needed for most *Hemiptera*. Plant bugs are rarely very active. Scale insects and mealy wings can only be collected on their food-plants and special attention has to be paid to rearing adults, parasites, etc. Sharp eyes are needed for collecting *Hemiptera* and not much more.

The above summary may help the beginner, but will not help the specialist in any order. Every naturalist finds his own methods; I am satisfied with the benzened cork tubes for a killing bottle, a knife, a lens, and a supply of boxes. If I am hunting *Neuroptera* or grasshoppers or wasps, I take a net. When a special group is to be studied, I use such special methods as my general experience has taught me suit

that group, but it serves no useful purpose to expound special methods which are familiar or unsuited to those who work on special groups.

Killing.

The entomologist must have good killing methods, or his specimens are useless. The ordinary cyanide bottle is good and precautions must be taken to keep it dry inside.

I prefer a mixture of benzene and chloroform in equal parts, with a few drops of citronella or bergamot oil added. (B. C.) A wide-mouthed bottle with wads of blotting paper damped with this mixture is very good, and I find it suits all groups equally well.

For laboratory material or for dissecting, heat or absolute alcohol give good results for most insects.

Tobacco smoke will, if nothing else be available, kill many small insects; *Hymenoptera* especially curl up almost at once.

Setting, Pinning, Mounting.

Having killed one's specimens, the next thing is to set them. There again a treatise is required to cover all the special methods, and no attempt is made to do more than outline the subject. Experience and many failures teach more than a volume can do and many specimens must be ruined before this can be mastered.

Pins are of various kinds. The ordinary insect pin, white or enamelled black, is the best, and one may use them entirely or use Carlsbad or long American pins. Steel pins, enamelled black, are not reliable as the enamel comes off and the pin rusts through. D. F. Tayler or Kirby Beard and Co. make ordinary pins and Tayler's Nos. 2, 3, 7, 12, 16 and 20 cover practically all needs. In pinning, the point is to have one-third of one's pin above the insect and the rest in and below it. It is usual to pin *Orthoptera* in the middle of the thorax or through the right wing; *Neuroptera*, *Hymenoptera*, *Lepidoptera* and *Hemiptera* through the thorax; *Coleoptera* through the right wing-case so that the pin does not pierce the right hind leg.

Small insects are often very troublesome to mount and set, and there are special methods for them.

Staging consists in pinning the insect with a fine pin on a slip of *polyporus* pith; the pith is then pinned with a big pin. Any compact white pith will do.

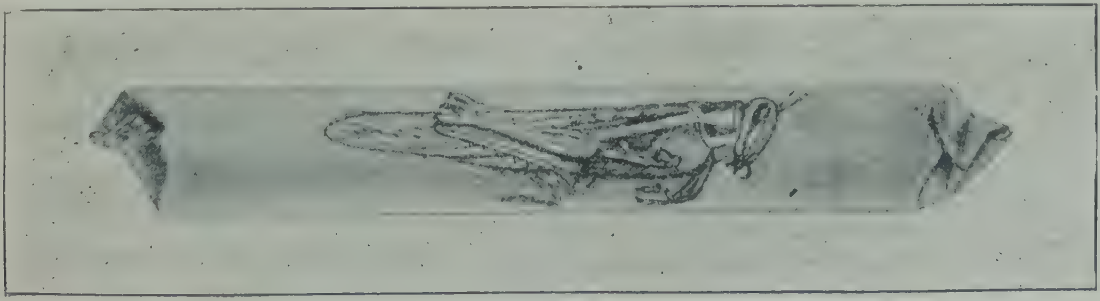

FIG. L.
Locust packed in paper cylinder.

Gumming consists of fixing the insect to a slip of card, and pinning that with a big pin. White gum is used, as little as possible being taken. The cards used here are rectangular, as narrow as possible,; others prefer triangular points.

On Card.—This is a method of pinning flies ; a disc of card is taken, cut with a 20-bore gun-wad punch, and a fine (No. 20) pin passed through ; the pin is then carefully pushed through the thorax of the fly *from below,* so that the point projects above. The card is then pinned with a big pin in the opposite way (fig. K).

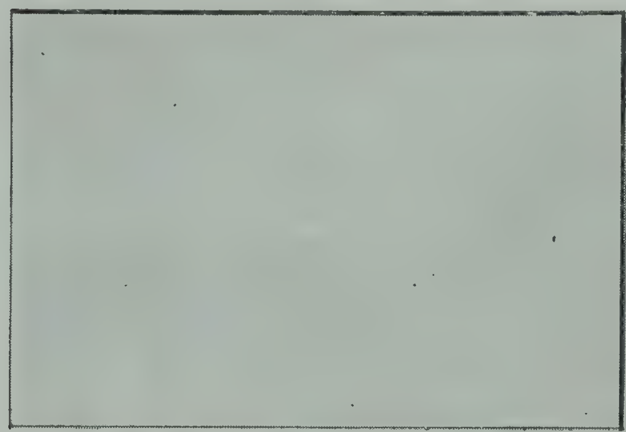

Fig. M.
Paper cut for folding.

The last method is used only for *Diptera ;* gumming is used for small *Coleoptera ;* staging for small *Orthoptera, Neuroptera, Hymenoptera,* medium *Coleoptera,* and for *Hemiptera.* Small *Lepidoptera* require special pins.

Many very small insects can only be kept in small corked tubes ; the inside of the corks should then be dipped in a solution of naphthalene, in benzene, or in carbolic acid.

Relaxing consists in keeping the specimen for 12 hours or more in a damp box till *rigor mortis* has passed off and the wings, legs and antennæ are flexible. A small quantity of acetic or other acid in the box helps to preserve the colour.

Setting *Lepidoptera* requires setting boards and one may adopt any of the methods, high setting being perhaps the best after the manner of the British Museum.

Other groups when pinned should have their legs and antennæ carefully arranged so as to be natural and so as to be readily examined by a lens.

Once an insect is mounted and dried, it is brittle and cannot easily be reset, so the arrangement of the legs, antennæ and wings is important. Specimens should be as natural as possible. The wings of *Neuroptera* should be spread as in the case of *Lepidoptera.* In grasshoppers the left wings of one specimen should be spread. Specimens should be set in different ways, some with wings open, some with wings as they are normally when at rest, the object being to display the insect and to preserve its natural habit of body. Having set the specimens, dry them. No insect should be stored till it is perfectly dry and the lack of this means a certainty of moulds sooner or later. In the monsoon, a proper drying box containing calcium chloride or lime is very valuable, if not essential.

Labelling.

A specimen without a label may be thrown away, as it is useless. Labelling should be done at once as there will then be no confusion. It would be a good thing if all entomologists labelled in the same way, and the best system of labelling is as follows :—

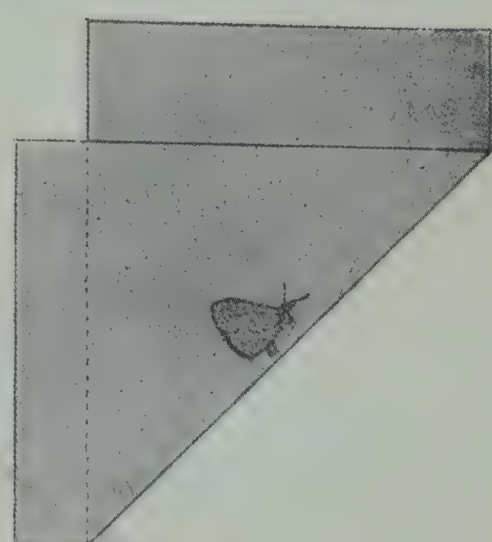

Fig. N.
Moth or Butterfly in paper.

The labels used are of stout white paper or thin card ; the number, date of capture, name of food-plant, and locality are written on the label and at one side the name of the collection. The collector's name is on a separate label if the specimen is sent to

the Museum, and all Museum specimens bear the Museum label. In putting locality one must be precise. The village, taluka, or town, the province, and "India" must all be placed on the label, as a specimen labelled "Hyderabad" may be from one of two places, and the entomologist in Europe or America to whom a specimen may go does not necessarily know that these places are in India.

Labelling like setting is done with a view to posterity and collections now made may be in a Museum for centuries and may go to any part of the world eventually.

If the insect's name is to be on a label, it should be on a separate label of a distinctive colour. There may then be three labels, the collector's name, the full details on a collection label, and the name of the insect, with the name of the person responsible for naming, followed by an exclamation point!

Storing.

Insects after being pinned, labelled and set are stored in corked boxes. Boxes must be air-tight and well corked and papered.

Naphthalene or other "insectifuges" must be placed in the box. The difficulty in India is not excluding insects so much as excluding damp, and it is at this time that the value of drying insects thoroughly is apparent. Any moisture in the insect leads to mould when the atmosphere round it is moist also, and the surest guard against mould is thorough drying before placing in the store box.

It is unnecessary to pin all of a collection if there are duplicates. Spare *Lepidoptera* are best kept in "papers," spare *Orthoptera* in cylinders (fig. L), and spare beetles in sawdust or bran. They can then be relaxed and set if wanted for the pinned collection, or are readily sent by post unpinned.

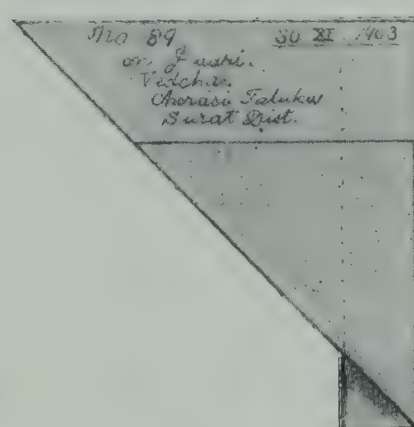

FIG. O.
The finished paper.

Caterpillars, etc.

Larvæ of all kinds are best preserved in alcohol, alcoholic mixtures, or formalin. Special methods must be used for obtaining laboratory material for dissection, etc. Rectified spirit of 70 per cent. alcohol is the best form of spirit; a mixture of alcohol, spirit and glycerine preserves larvæ well and keeps them in a good flexible state. Caterpillars are best blown with a larva blowing apparatus or over a spirit lamp and small oven. A solution of 4 per cent. formalin in water is good for most larvæ. A handy way of storing larvæ is in tubes, 3 inches long by 1 inch in diameter, with a good cork. The label should be inside the tube written with hard pencil or good ink and it is useful to have the insect's number on the cork or on the outside for ready reference.

Arrangement of Collection.

In making a collection of pinned insects, the difficulty lies in allowing for expansion. However much room one allows for future specimens, one cannot be sure that the arrangement will meet future needs simply because one cannot foresee what will come in. It is perhaps best to allow at first for a small expansion only and then presently transfer the whole collection, leaving a large space for fresh accessions. Where all families are collected, it is well to start a box for each order, expanding those orders

into boxes assigned for each big family and groups of small ones. For this reason store-boxes are better for keeping permanent collections in than cabinets with drawers, as new boxes can be put in anywhere and new drawers cannot always be inserted.

In making a general collection it is wiser to separate the orders, and not, for instance, to put the parasites of a species of moth with the specimens of that moth. If the moths are the object of the collection, then the parasites can fitly be placed with the species they prey on.

It is important to put name labels on the pins and not simply below each species; there may be a generic label at the head of a genus and a specific label below each species in addition.

Special Material.

All specimens cannot be either pinned or in spirit; there must be a quantity of special material unsuitable for either. Eggs, pupa cases, cocoons, specimens illustrating the habitations of insects must be kept separate in boxes or bottles as a rule. For small objects, eggs, pupa cases, small cocoons, etc., glass topped boxes are useful. A small quantity of naphthalene helps to preserve them. Duplicate insects also want special storing, as the *Lepidoptera* in papers, *Coleoptera* in sawdust, *Orthoptera* in cylinders. *Coccidæ* keep well in small envelopes wrapped in oiled paper, as do the pupæ and larvæ of *Aleurodidæ.* Small *Hemiptera, Hymenoptera, Diptera,* can often be best kept in good corked tubes, as can small duplicate *Coleoptera*; but they must first be well dried, and the outside of the corks should be varnished or dipped in melted paraffin wax. A dry specimen should always be in an atmosphere of naphthalene or carbolic acid; the inside of corks of tubes should be dipped in carbolic acid or in a solution of naphthalene.

In working microscopic specimens, a series of slides accumulates of insects in Canada balsam. These are kept in special cabinets and it is convenient to number them in order as they are made and list them separately in a book.

Rearing.

A volume could be written on this subject to deal with the different families and their peculiar needs. There is but one rule, to keep the insects as much as possible in natural conditions. This can never be fully attained in a small space or even in the biggest cage indoors. Many cannot be reared in captivity save under exceptionally good conditions; others will live under very bad conditions. *Lepidoptera* are among the easiest unless they are such as some of the *Lycænidæ,* which miss the attendance of their particular species of ants. Plant-feeding caterpillars want plenty of fresh food, proper conditions of light, air and moisture, and whatever particular conditions they require for pupation.

Diptera are often easy, provided they are not allowed to dry up. Most predaceous forms, *Mantidæ, Hemerobiidæ, Coccinellidæ,* need a very large supply of food and even then are not always easy to rear.

Larger plant-sucking *Hemiptera* need live plants to feed on and then thrive very often. Smaller *Hemiptera* are easy to rear, save such forms as *Jassidæ.* Many species of *Orthoptera* can be reared but will not breed in captivity; the same is true of the majority of *Coleoptera* and *Hemiptera.*

Aquatic insects demand special methods usually easily obtained if the insects are accustomed to stagnant water but almost impossible for such as live in swiftly running water.

Boring insects are easy to rear but will not breed readily, unless they are *Lepidoptera.* Galls are exceptionally difficult to manage, and I have found Dr. Sharp's suggestion of always having a little carbolic acid to vapourise in the jar or cage a good one.

FIG. P.
Field cage, three feet cube.

For breeding cages and jars, there is no standard. For small insects cages made of perforated zinc with a sliding glass lid are very good, and are also handy for travelling. From these up to cages 6 feet high there may be an indefinite series according to the object in view. Many small species need nothing more than a glass-topped box or a glass jar.

Cleanliness, plenty of fresh food, a liberal provision of air, light, dry or damp earth and shelter are the chief things to be looked for in rearing insects.

Notes.

It is a sound plan to work entirely by numbers, giving each *species* a serial number and using that for all specimens of that species, and for all notes. All the records concerning pests are kept by numbers and the various species are known by number throughout. This rarely entails confusion when two closely allied species are confused under one number, and even this can be avoided by giving a fresh number to a new batch of what one thinks may be a familiar species, till one is sure it is the same. No harm is done by having one species under several numbers till one is sure they are the same, as it is an easy matter to put them all under one number at any time.

Notes habitually and regularly taken include field notes, notes from rearing cages, notes of specimens sent in, notes from literature, and a note of all the specimens that are in the collection relating to that one species. By bringing these all together in one place one has at a glance the whole history of each species so far as it is known.

A separate index of food plants and a systematic index then become necessary so that one may at a glance find all the pests of a particular crop, or all the insects of a particular family that one has in the collection.

I prefer to keep nearly all this information on cards, in a card catalogue series, and only rearing notes and field notes are entered separately and then condensed on to the regular card series. The methodical collection of all information is a great part of any continuous entomological work and for lack of it a great deal of work has been lost. I have not space to describe the card system in use; I am convinced that methodical and careful note taking is of the greatest importance if one aims at anything higher than a mere collection of dried specimens. The most trivial things may later on be found to be of the utmost importance and one racks the memory in vain to remember the precise details.

Formulæ.

1.—B. C. bottle.

Benzene		Equal parts. Add a few drops of oil of bergamot or other essential oil.
Chloroform		

Killing fluid for Aptera.

Absolute alcohol	Equal parts.
Glacial acetic acid	

Formalin.

Formic aldehyde 40°/ₒ (Formol)	1 part.
Water	19 parts.

Cement.

White gum arabic	In equal parts, powdered, with enough water to make a paste, and a few drops of carbolic acid.
White gum tragacanth	

Gum for labelling glass bottles.

Aluminium sulphate	2 grams	Dissolve.
Water	20 grams	
Gum arabic	74 grams	Dissolve.
Water	180 grams	

Mix the two.

Preserving fluid.

Alcohol, 95%	2 parts	Add ½ per cent. of acetic acid to finished mixture.
Glycerine	1 part	
Water	1 part	

2.—Killing bottle.

Cyanide of potassium	1 oz.
Plaster of Paris	4 oz.

Place the cyanide in the bottle, cover with half the plaster. Mix the rest of the plaster to a cream with water, and quickly pour over the dry plaster and cyanide in the bottle.

Apparatus.

Nets.—The ordinary kite or balloon net serves most purposes, but a small light net with a bag of light material may be needed for small *Hymenoptera, Diptera,* etc.

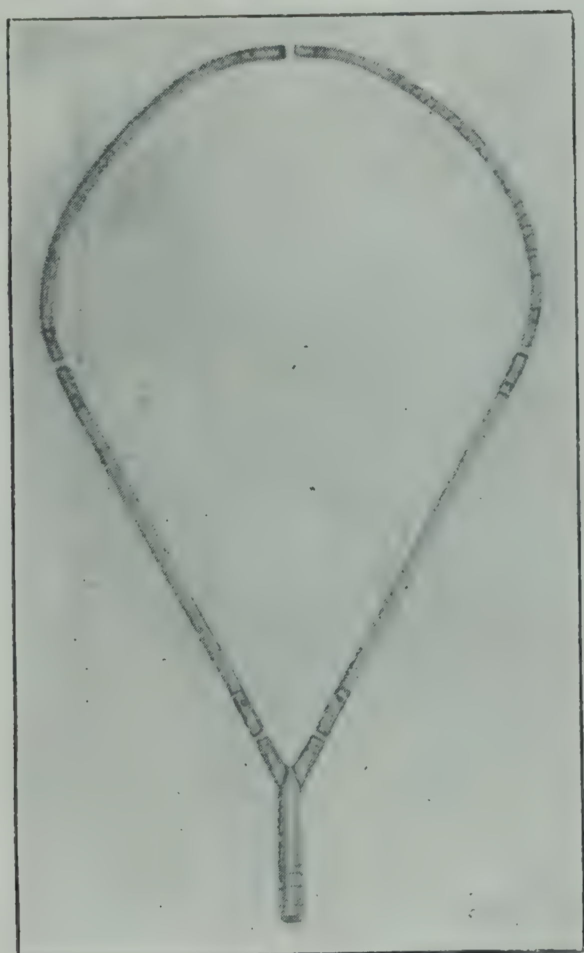

FIG. Q.
Frame of kite net, of cane with brass ends.

For aquatic insects, a stout net, inside lined with fine muslin and outside with coarse holland, with a bottle at the bottom is most suitable.

Pill boxes.—For collecting these should be glass bottomed, round, nested boxes, of cardboard. Before use they should be varnished outside with shellac dissolved in alcohol to preserve them from damp.

Glass topped boxes.—The handy sizes are $\frac{3 \times 3 \times 2}{5 \times 5 \times 2\frac{1}{2}}$; they should be of cardboard with glass top, and also varnished outside.

Tubes.—Glass tubes, well corked, are the handiest things for general collecting. Two sizes are useful, 3×1 inch, and $2 \times \frac{5}{8}$ inch.

Killing bottle—Is best made with a well stoppered, wide-mouthed bottle as described above.

Knife.—A good knife is essential.

Pins.—D. F. Tayler's Nos. 2, 3, 7, 12, 16, and 20, meet all ordinary requirements.

Store boxes.—A useful size is $17\frac{1}{2} \times 12 \times 3\frac{1}{2}$; thin sheets of cork $\frac{3}{8}$ inch thick are used for lining, covered with white paper. There should be a cell in one corner for naphthalene.

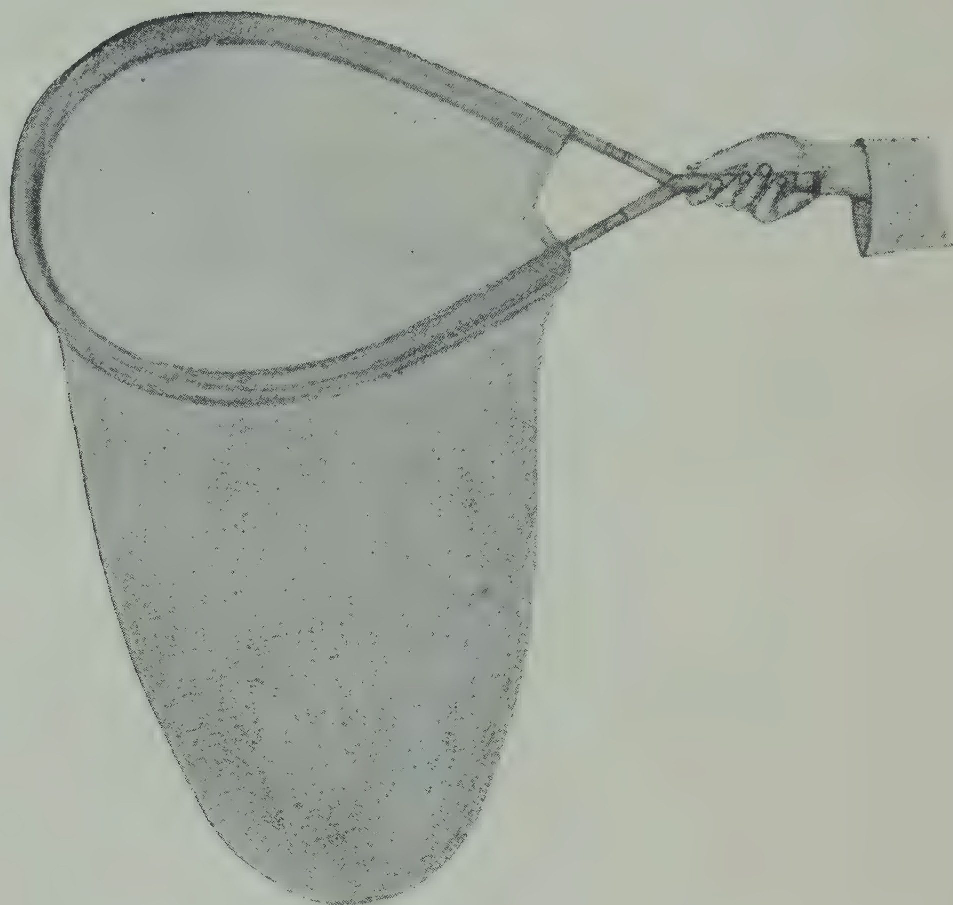

Fig. R.
Kite Net.

Forceps—Are useful for handling fine insects, they should be long and curved, with fine points. Coarser curved or bent forceps are useful for handling pinned insects.

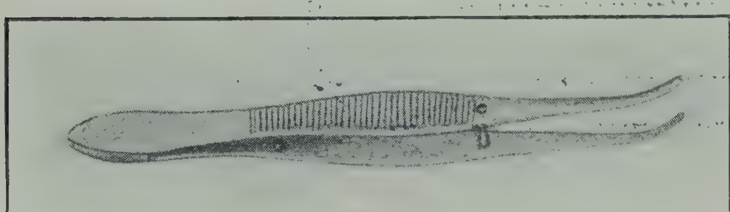

Fig. S.
Forceps for handling small insects ; pinning forceps have broader points.

Punch.—A 20-bore gun-wad punch is useful for cutting discs of white card for mounting flies.

Lens.—A good aplanatic magnifying 10 to 16 diameters is essential for small insects.

Setting boards.—These may be obtained in the flat form for high setting, in the flat for low setting or in the oval form for low setting. Flat setting boards in either form are preferable to oval.

Pith.—Polyporus pith (imported) is a very good material for staging small insects. At a pinch any good tough pith will answer.

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G. I. C. P. O.—No. 2 Ento.—14-8-1906.—450.—J. J. M.

ACC No. 24444

ಗ್ರಂಥಾಲಯ
ಲಾಲ್‌ಭಾಗ್, ಬೆಂಗಳೂರು

ಡಾ॥ ಎಂ.ಹೆಚ್.ಮರೀಗೌಡ ರಾಷ್ಟ್ರೀಯ ಗ್ರಂಥಾಲಯ
ಲಾಲ್‌ಬಾಗ್, ಬೆಂಗಳೂರು – 560 004

ಪ.ಸಂಖ್ಯೆ: 2461 ವ.ಸಂಖ್ಯೆ:........................

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ಪು.ತಿ.ನೋ..

ವ. ಸಂಖ್ಯೆ ____________________

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ತೋಟಗಾರಿಕೆ ಇಲಾಖೆಯ
ಗ್ರಂಥಾಲಯ

ಲಾಲ್‌ಬಾಗ್, ಬೆಂಗಳೂರು-560 004